OVEMBER 1960

LUME 3 • NUMBER 11

- Hechtel — Electrostatic Focusing of Microwave Tubes
- Lax & Button — Electromagnetic Properties of Ferrimagnetics and Their Applications from UHF to Millimeter Waves — Part III
- Elfving, Franks & Lamberty — Methods of Automatic Analysis and Synthesis of Polarization of Electromagnetic Waves
- McMillan & Schmitt — Doppler Method for Absorber Testing

the microwave journal

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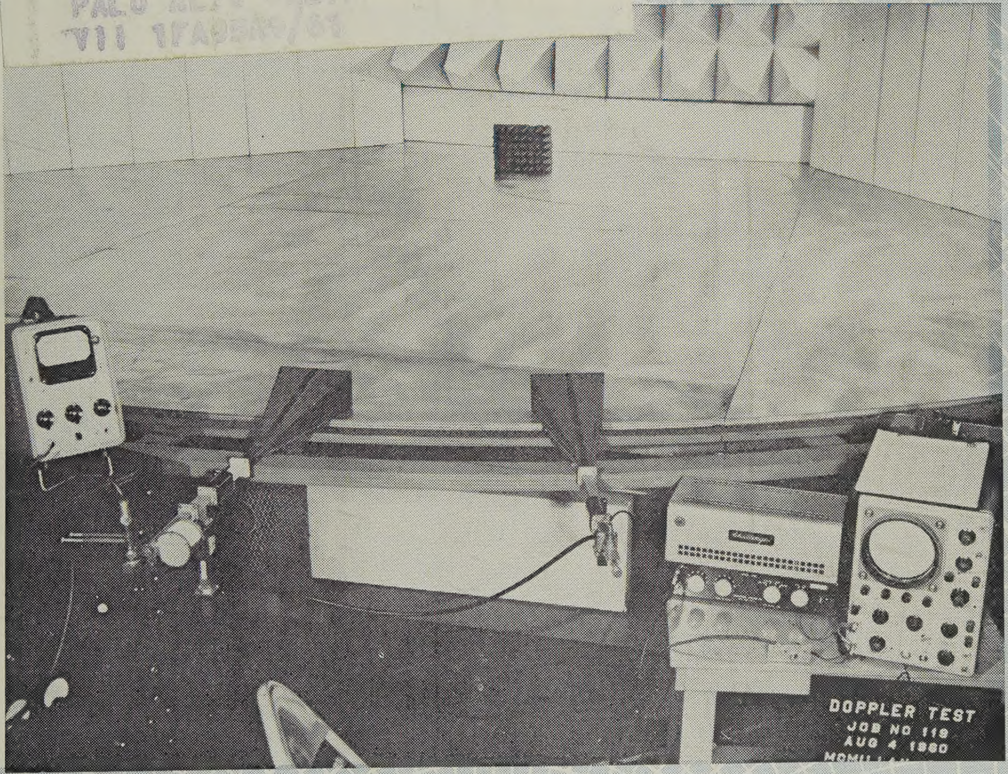


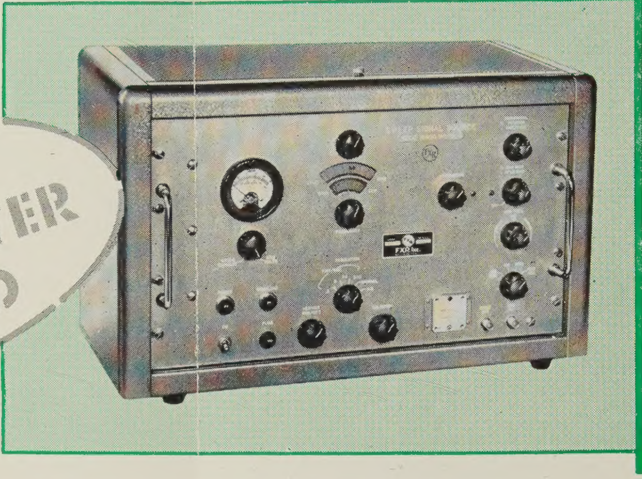
Starting In This Issue

LECTROSTATIC FOCUSING OF MICROWAVE TUBES

new

X-BAND SWEEP SIGNAL SOURCE

8,200mc to 12,400mc Frequency Range



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- ☑ **ELECTRONIC SWEEP**
- ☑ **AUTOMATIC GAIN CONTROL**
- ☑ **DIRECT READING FREQUENCY DIALS**

> *"If a man's work be true and good... challenging comparison will be his strength."*
>
> *David Charles*

The FXR Model X775A X-Band Sweep Signal Source, challenging comparison, is unsurpassed for the measurement of VSWR and reflection coefficient. The Model X775A utilizes a permanent magnet BWO as the rf source. A unique built-in AGC amplifier produces a flat rf level, with respect to a bolometer detector, over the entire swept frequency range. Both ends of the swept frequency range can be accurately preset on separate direct reading frequency dials.

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- **OUTPUT POWER:** 0 to 20mw minimum cw into matched load, continuously adjustable. With AGC-detected output flat to ±0.5db (when used with matched bolometers and directional couplers), therefore, no ratiometer required.
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  ±2% — sweep frequency operation.
- **OUTPUT CONNECTOR:** 1 X ½ waveguide.
- **POWER REQUIREMENTS:** 115/230V, 50/60cps, 200 watt.
- **DIMENSIONS:** 12⅞" high X 21¾" wide X 18" deep.
- **WEIGHT:** 78 lbs.
- **PRICE:** $2,900.00

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contact your FXR representative.

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FERRITE ISOLATORS

Model 157

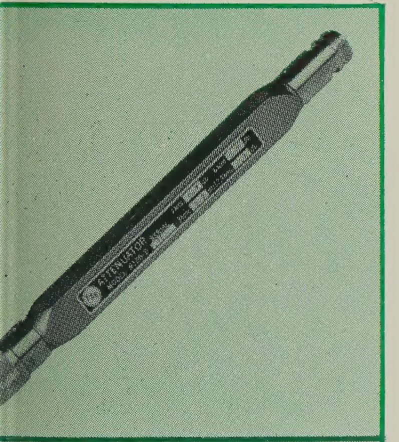
- **Waveguide Sizes from 3.95 to 26.0 KMc.**
- **Coax from 2.0 to 4.0 KMc.**
- **Full bandwidth operation.**
- **Isolation 10 to 30 db depending on frequency range.**
- **Insertion loss 1 db max.**
- **VSWR 1.15 max. waveguide; 1.2 max. coax.**

> *"Promises may get thee friends; but non-performance will turn them into enemies."*
>
> *Ben Franklin*

The growth of FXR in the microwave industry is ample proof that product performance has fully supported product promises.

This holds true for the specifications of these fine new components, which represent the latest advances in their respective types.

Prompt deliveries are also a promise.



FIXED COAXIAL ATTENUATORS

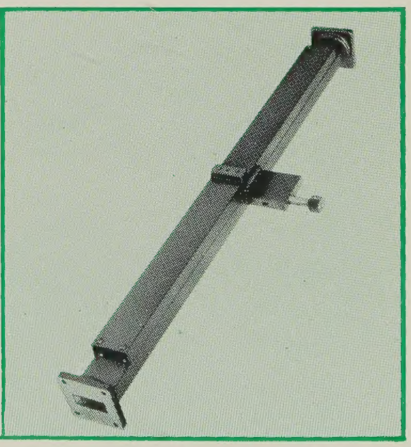
Model 180

peration from 1 — 12.4 KMc.
2 to 12.4 KMc for 20 db)
ttenuation Values 3, 6, 10, 20 db.
ow VSWR and frequency sensitivity.
ype N connectors.

STANDARD STEP ATTENUATOR

Model X176

- **Step loss (by pushing rod) 40 db.**
- **Calibration and frequency sensitivity ±0.4 db max.**
- **Full waveguide operation from 8.2 to 12.4 KMc.**
- **Stability dependent only on coupling through holes in waveguide.**
- **VSWR 1.1 max.**
- **Insertion loss 0.5 db max.**



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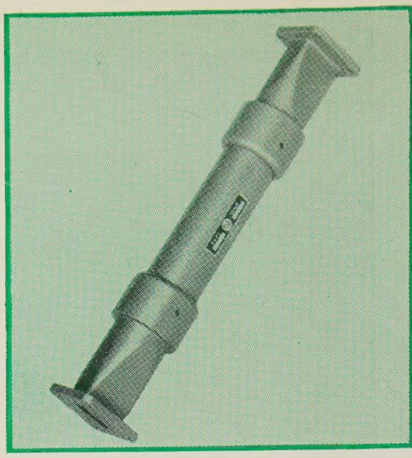
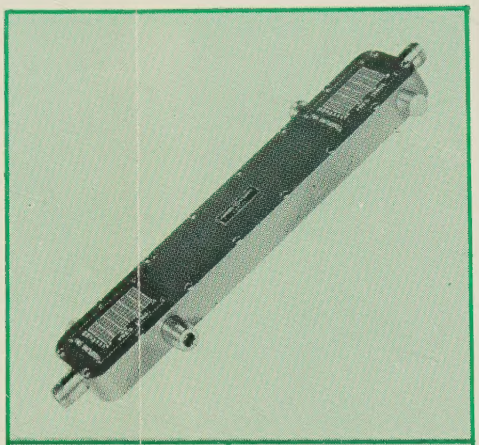


FIXED PRECISI
ATTENUATC

Model

- Operation over full waveguide frequency
  ranges.
- Full range of sizes from 2.6 to 90 KMc.
- Stability dependent only on locked mecha
  setting.
- Frequency sensitivity ± 0.3 db to 20 db
  ± 0.5 db 20 to 30
- VSWR 1.15 max.
- Factory set values from 0.5 to 30 db.



COAXIAL BROADBAND BIDIRECTIONAL COUPLERS

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  617 — 1000 to 4000 Mc.
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- Directivity 20 db min.
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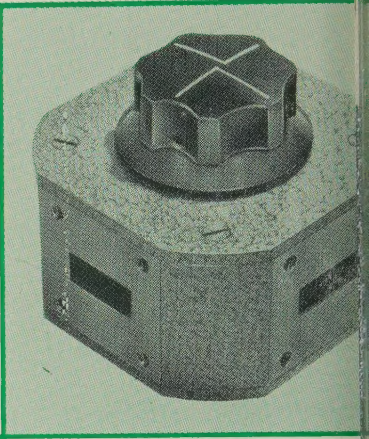
- Operation over full waveguide freq. ranges.
- Full range of sizes from 2.6 to 40.0 KMc.
- Crosstalk 60 db min.
- VSWR 1.10 max.
- Manual or solenoid operation.
- High power capacity.



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PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQU

Detecting The Invisible Half of Matter

An overwhelming percentage of space is a relative void, but drifting in that void are vast seas of rarified material, known as the interstellar medium. The amount of material in the interstellar medium is comparable with the total mass of the stars and is composed primarily of gas and dust. Giant radio telescopes, combined with the most sensitive radio devices ever constructed, are probing the interstellar medium. In this manner, radio astronomers seek answers for some of the most provocative questions posed by science.

Because interstellar space is so very cold, the major portions of the interstellar medium are optically invisible. For the most part, the presence of the medium can be detected only by radio astronomical techniques which are capable of measuring the minute amount of radio energy generated in space. Spectral line radiation from the interstellar medium is the most profitable area of study.

The gas which has been the main research objective is atomic hydrogen. A hyperfine transition in the ground state of the hydrogen atom occurs at a frequency of 1420.40572 ±0.00001 Mc. Around the Milky Way, the hydrogen line appears in emission. In the direction of discrete sources (radio stars) the line is reversed and appears in absorption. Signal powers produced by this radiation at the terminals of an antenna are usually of the order of 10^{-18} watts; therefore, extremely high receiver sensitivities are required for research programs.

The study of this radiation is being vigorously pursued at the major astronomical observatories of the world. Objectives of the research programs include a measurement of the mass of the Milky Way, measuring the distance from the earth to the sun, determining distances to radio stars, mapping the spiral arms of the Milky Way, measuring the interstellar magnetic field, and measuring the gas content of island universes at very remote cosmic distances. A precise determination of a hydrogen line profile is critical for all these research programs. To accomplish this determination, a radiometric system must be extremely stable, ultra-sensitive, retain "flat" critical RF parameters while scanning, and operate reliably and dependably.

The development and manufacture of receiving systems meeting requirements such as those described above has been Ewen Knight's major activity for a decade. Ewen Knight radiometric systems are in daily operation at the leading radio astronomy laboratories in the Americas. Other systems, destined for giant radio telescopes now under construction in the United States, are now taking form at Ewen Knight. Similar receivers are being developed for missile trackers and radiometric navigation systems. Our staff, accustomed to "frontier" demands, stands ready to translate your most complex solid state or conventional microwave system requirements into reliable instrumentation.

Ewen Knight CORPORATION

AT THE FRONTIERS OF *Electronics*

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Olympic 3-3300

NOVEMBER, '60 vol.3 - no.11

the microwave journal

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Survey of Electronically Scanned Antennas

Effects of External Noise on Radar Performance

Electrostatic Focusing of Microwave Tubes, Part II

Control of the Amplitude and Phase of an Electromagnetic Wave in a Waveguide by Means of a Germanium Plate

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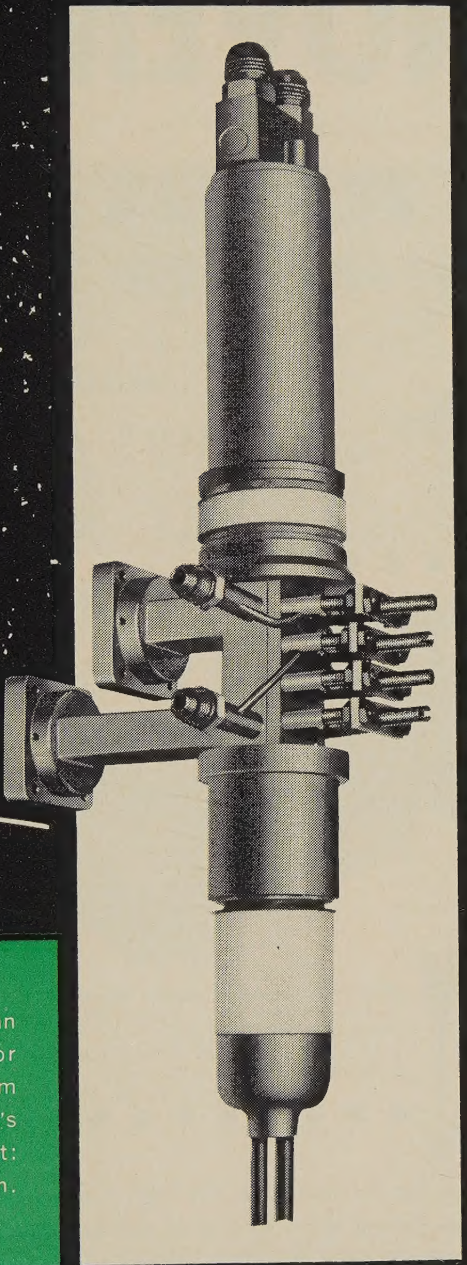
BPA

for space systems

20kW CW at X-band



Varian's new VA-849 amplifier klystrons are rated to deliver higher CW power at X-band than any existing tube in the world . . . 20kW!

Varian's new VA-849 power klystron opens up a variety of new design approaches to space systems. Possible applications exist in communication concepts such as repeater satellites, moon-bounce signalling, or in reflections from clouds of tiny orbiting needles. Radio astronomers, too, will welcome the VA-849.

Immediate applications include CW radar and illuminator service. Low incidental noise. Water cooling. Electromagnet focusing. Another significant advance In microwave components from Varian's broad experience and research in super-power tubes.

FEATURES

- **7.125 to 8.5 kMc**
- **20 kW CW**
- **50 db Gain.**
- **30 Mc Minimum Bandwidth**
- **Tunable 60 Mc.**

It's likely that Varian can provide a solution for your particular system design problem. There's a good way to find out: write Tube Division.

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KLYSTRONS, WAVE TUBES, GAS SWITCHING TUBES, MAGNETRONS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, MICROWAVE SYSTEM COMPONENTS, NMR AND EPR SPECTROMETERS, MAGNETS, MAGNETOMETERS, STALOS, POWER AMPLIFIERS, GRAPHIC RECORDERS, RESEARCH AND DEVELOPMENT SERVICES.

Vance Packard notwithstanding, status has its moments. It was during our early college years that we felt a '26 Durant was just as good as a '32 LaSalle and "the hell with keeping up with the Joneses" (so to speak). Today, whether it is a result of the maturing process or just because we've become a great deal more acquisitive, we don't mind at all being identified as "that guy with the Chrysler 300F". As a matter of fact, we rather enjoy it.

Status, we should hasten to add, is not just limited to the social scene but plays quite a role in the professional life of the engineer. Although we have fought this at Rantec by giving no one a title to lord over his fellow man (taking the constant risk, by the way, that we will have all chieves* and no indians), it is, we fear, a losing battle. A man will crawl up that ladder even if you eliminate the ladder. Very constant fellow, very constant indeed.

This brings us around to a rather enticing bit of news for all status seekers, whether they be secretive or out in the open. A gentleman we know (he shall go nameless) has some items absolutely guaranteed to increase the status of any engineer. For only $199 he is selling all back issues of the Proceedings of the IRE (in good condition) since the inception of the publication. Imagine the effect! Bookcases crammed full of technical knowledge, all of which you have obviously devoured and absorbed. Rather than bookcases, we suggest merely stacking them willy-nilly in corners. The effect is quite disastrous. For an additional $150, you can have the entire set dog-eared and thumbed to eliminate any possibility that whoever *might* be in your office at the time *might* think you *might* not have read each and every page of the contents.

For an additional $300, you can have all issues of Playboy with Playmates intact bound in PGMTT covers.

Rantec, we hasten to add, is not in the business of selling Proceedings, PGMTT or Playboy. What Rantec sells, off and on, are antennas, microwave ferrite devices, waveguide components and r-f telemetry components. If you happen to know anything about any of these fields, why not give us a call. We might be able to loan you one of the sets of Proceedings. We bought out the man's entire stock.

*status spelling.

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RANTEC'S HIGH-POWER CIRCULATOR

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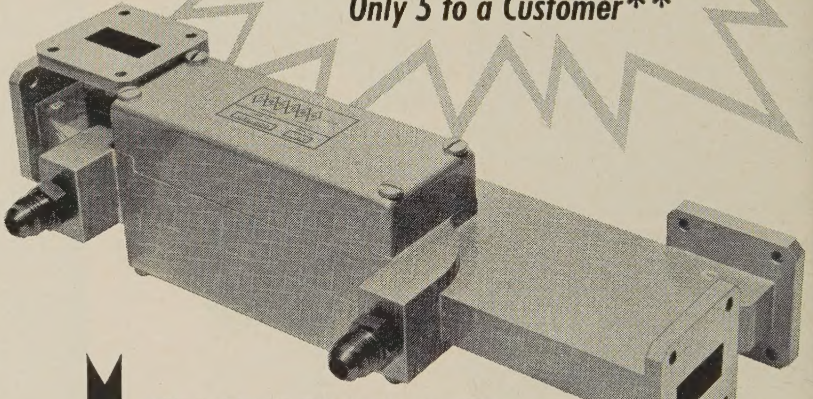

SPECIFICATIONS FOR MODEL CXL—200

Frequency 8.5-9.6KMC; Isolation 20db min.; Insertion Loss 0.6db max.; VSWR 1.2:1 max.; Power Handling 1 megawatt peak, 1000 watts average; Cooling, water jacket; Delivery 30 days ARO.

Now, for the first time, the high-power circulator millions have been waiting for . . . at a price you can afford. Nowhere else will you find quality like this at a price so low, low, low! Ask the man who owns five!

Rantec Corporation, Calabasas, California

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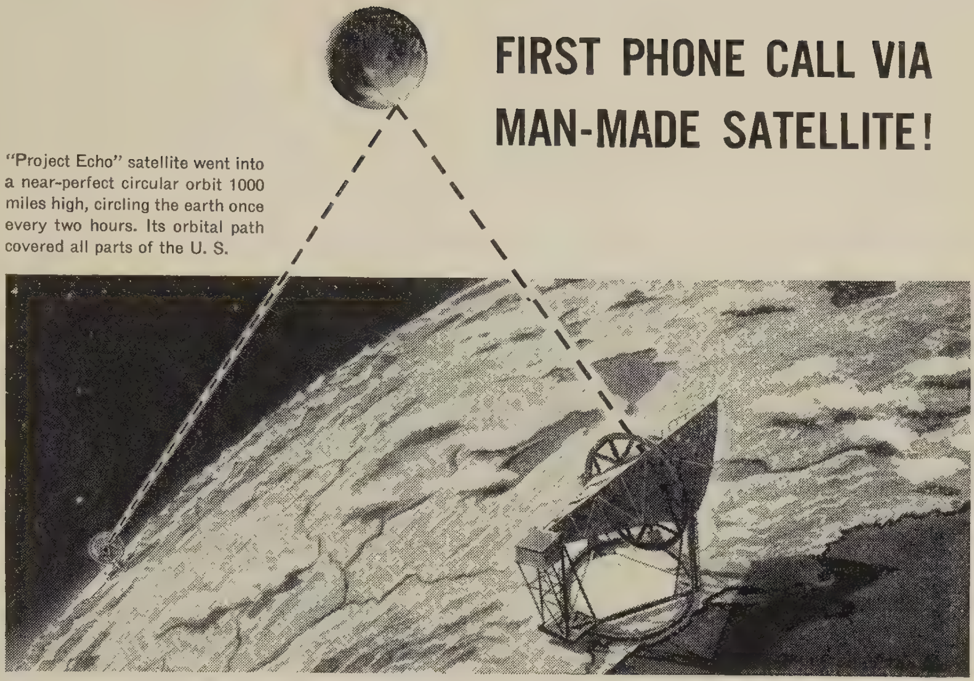
**and the eleven remaining months of the year*

***unless you might wish to have six or more*

FIRST PHONE CALL VIA MAN-MADE SATELLITE!



"Project Echo" satellite went into a near-perfect circular orbit 1000 miles high, circling the earth once every two hours. Its orbital path covered all parts of the U. S.

BELL TELEPHONE LABORATORIES BOUNCES VOICE OFF SPHERE PLACED IN ORBIT A THOUSAND MILES ABOVE THE EARTH

Think of watching a royal wedding in Europe by live TV, or telephoning to Calcutta—*via outer-space satellites!* Once a mere dream, this idea is now a giant step closer to reality.

Bell Telephone Laboratories recently took the step by successfully bouncing a phone call between its Holmdel, N. J., test site and the Jet Propulsion Laboratory of the National Aeronautics and Space Administration (NASA) in Goldstone, California. The reflector was a 100-foot sphere of aluminized plastic orbiting the earth 1000 miles up.

Dramatic application of telephone science

Sponsored by NASA, this dramatic experiment—known as "Project Echo"—relied heavily on telephone science for its fulfillment . . .

- The Delta rocket which carried the satellite into space was steered into a precise orbit by the Bell Laboratories Command Guidance System. This is the same system which recently guided the remarkable Tiros I weather satellite into its near-perfect circular orbit.
- To pick up the signals, a special horn-reflector antenna was used. Previously perfected by Bell Laboratories for microwave radio relay, it is virtually immune to common radio "noise" interference. The amplifier—also a Laboratories development—was a traveling wave "maser" with very low noise susceptibility. The signals were still further protected from noise by a special FM receiving technique invented at Bell Laboratories.

"Project Echo" foreshadows the day when numerous man-made satellites might be in orbit all around the earth, acting as 24-hour-a-day relay stations for TV programs and phone calls between all nations.

This experiment shows how Bell Laboratories, as part of the Bell System, is working to advance space communication. Just as we pioneered in world-wide telephone service by radio and cable, so we are pioneering now in using outer space to improve communications on earth. It's part of our job, and we are a long way toward the goal.

BELL TELEPHONE LABORATORIES
World Center of Communications
Research and Development

MICROVIEWS

OF THE MONTH

41 ▶ ELECTROSTATIC FOCUSING OF MICROWAVE TUBES — Part I

J. R. Hechtel

The merits of electrostatic focusing of microwave tubes are summarized, and the basic electrode arrangements are considered. The first group of tubes described makes use of the electric field between coaxial cylinders. This group includes the magnetless magnetron, the helitron, the spiratron and tubes based on Harris flow.

49 ▶ ELECTROMAGNETIC PROPERTIES OF FERRIMAGNETICS AND THEIR APPLICATIONS FROM UHF TO MILLIMETER WAVES — Part III

Benjamin Lax and Kenneth J. Button

Part III reviews the latest advances in the design and performance of UHF circulators and isolators which operate at frequencies as low as 200 Mc and at high signal power. Ferrite and antiferromagnetic applications at millimeter wavelengths are described and the theoretical basis of this new field is outlined. The X-band reciprocal phase shifter in rectangular waveguide is described and analyzed.

57 ▶ METHODS OF AUTOMATIC ANALYSIS AND SYNTHESIS OF POLARIZATION OF ELECTROMAGNETIC WAVES

C. Elfving, R. Franks, B. Lamberty

In many applications, electronic system effectiveness may be enhanced if the polarization of an incident electromagnetic wave is analyzed and then synthesized in the antennas of the system. If the wave has random, variable or unknown polarization characteristics, this analysis requires determination of the three properties of polarization: axial ratio, sense of rotation, and orientation angle of the major axis of the polarization ellipse. This paper describes a method which can determine and synthesize these properties completely, and other methods which determine and synthesize only the polarization orientation angle property. A comparison is made of the relative effectiveness of complete and partial analysis and synthesis for different incident wave types and polarizations. Experimental models of two of the methods considered, namely, a method using analog techniques and a method employing discrete values of orientation angle, have been constructed and successfully operated. Photographs are shown of these models and experimental results are reported.

64 ▶ DOPPLER METHOD FOR ABSORBER TESTING

E. B. McMillan and H. J. Schmitt

The Doppler principle is adapted to measure the reflection of short electromagnetic waves from flat samples of absorbing material. The measurement equipment is described, and its performance compared with the more standard procedure. Typical results for the reflection from microwave absorbing material are discussed.

OUR COVER

Indoor test measuring of an individual piece of microwave absorber by "Doppler" method at McMillan Laboratory, Inc., Ipswich, Massachusetts. Test horns are shown mounted on image screen and aimed at absorber target. Target is mounted on small disc which rotates in countersense inside large turntable, thus keeping the absorber front always facing in one direction. This equipment gives reliable results even for absorber having low reflectivity. See page 64.

the
microwave
journal

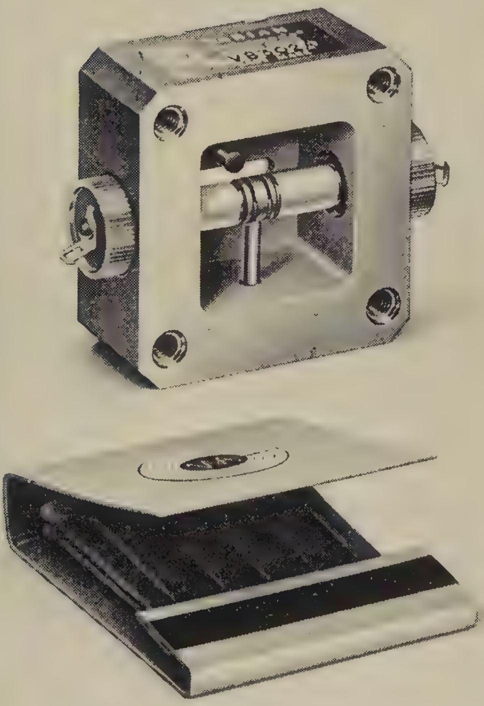
small

smaller

smallest

VARIAN ORTHOMODE® BALANCED MIXERS

X-Band C-Band S-Band



V-8302 A Orthomode® X-Band Balanced Mixer

Let's assume your particular design calls for the services of one of the smallest hybrid microwave mixers in the world. Must be rugged . . . perhaps you plan to fly it in a missile, or hook it into a back-pack radar system. Must be lightweight . . . something like ⅓ the weight of conventional magic-T or short-slot mixers. And must perform as well or better than big mixers.

Varian's new line of miniaturized Orthomode mixers beautifully meets these demands. Available in X, S, and C-bands, they're particularly suitable to airborne radar and missile applications where difficult packaging problems are always cropping up. And they include convenient lug terminals which permit crystal current monitoring without additional filtering.

FEATURES

- Models Cover 3.95 To 10.8 kMc Range
- Low Noise Figure
- Unusually Small Size and Weight
- Wide Band Without Adjustment
- Withstand Extreme Environments
- Simple To Install and Use

We'll be happy to provide additional technical data as to how this unique family of miniature Orthomode hybrid mixers can aid you. Just address Radiation Division.

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from the editor

STATISTICSMANSHIP

In one of our recent issues Nicholas Vanserg introduced — or rather, identified the art of mathmanship. At this time I would like to identify the art of statisticsmanship.

The art of statisticsmanship has been in use for many years. More recently, its use has increased to the point where today a good politician, advertising man, engineer, etc., would not dare leave the warmth of his home environment without first arming himself with a set of carefully analyzed statistics.

The art of statisticsmanship has to do with the ability to take a given set of statistics or preferably an isolated statistic and, by careful choice of phraseology and emphasis, to use it to prove any and all points. The high water mark of statisticsmanship usually occurs around election time when two politicians using identical statistics can prove, not infer, diametrically opposite points of view.

Let us consider a few simple illustrations to help clarify the point. Recently the first BPA audit of "the microwave journal" readership was completed with rather interesting results. Even more interesting are the conclusions that can be implied when these facts are subjected to statisticsmanship.

Did you know that, although Alaska is many times larger than Rhode Island, more than 19 times as many mwj's are sent to the latter? (Alaska — 2; Rhode Island — 39)

Did you know that Hawaii has a third more recipients of mwj than either North or South Dakota? (Hawaii — 4; North Dakota — 3; South Dakota — 3)

One of the most accepted techniques of statisticsmanship is the use of the implied meaning gambit.

(AGAINST) Did you know that "the microwave journal" has *no more than* 4400 recipients in New York? Or (FOR) Were you aware of the fact that *we already had well over* 4300 readers in New York alone? (New York — 4313)

More statistics . . . . . without statisticsmanship: After New York, the first five states in circulation are California — 3,658, New Jersey — 2,443, Massachusetts — 2,250, Maryland — 1,060, Pennsylvania — 1,046. Our circulation outside the 50 states: U.S. Territories — 3, Canada — 307, APO-FPO — 45, Foreign — 378.

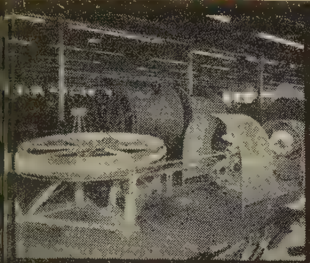
Our readers are divided as follows: 66 per cent R & D, 6.4 per cent management, 6 per cent application, 5.7 per cent military agency. The remainder is divided between civil agency, puchasing, production, education, sales, and other.

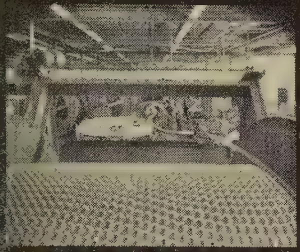
Total qualified circulation for our August issue — 21,117. Other supplementary facts we have culled out to date are interesting — with or without statisticsmanship. In terms of component breakdown (28 per cent of our readers, many of whom profess interest in more than a single component): Tubes — 13 per cent, Antennas — 21.5 per cent, Instruments — 14.9 per cent, Solid State — 15 per cent. Almost 49 per cent (48.8) profess to be interested in systems. Although the categories were not complete, it is interesting to note that 16 per cent were involved in communications and 2.9 per cent in radio astronomy.

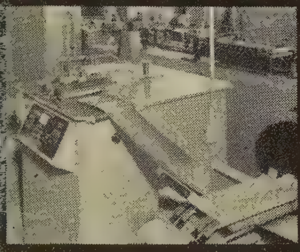
These are the facts. By applying the phrases "in excess of," "well over," "more than," "hardly more than," "considerably less than," "below," and many more such phrases that come to mind, one can imply whatever he wishes, using the fine art of statisticsmanship.

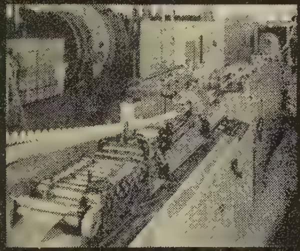
Ted Saad

roduction scenes

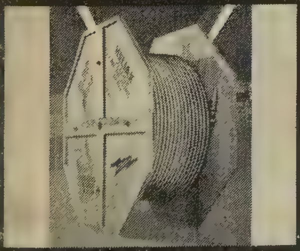

Applying insulation to inner conductor


Take up of cable core


Splice welding strip stock


Forming and welding outer conductor over cable core

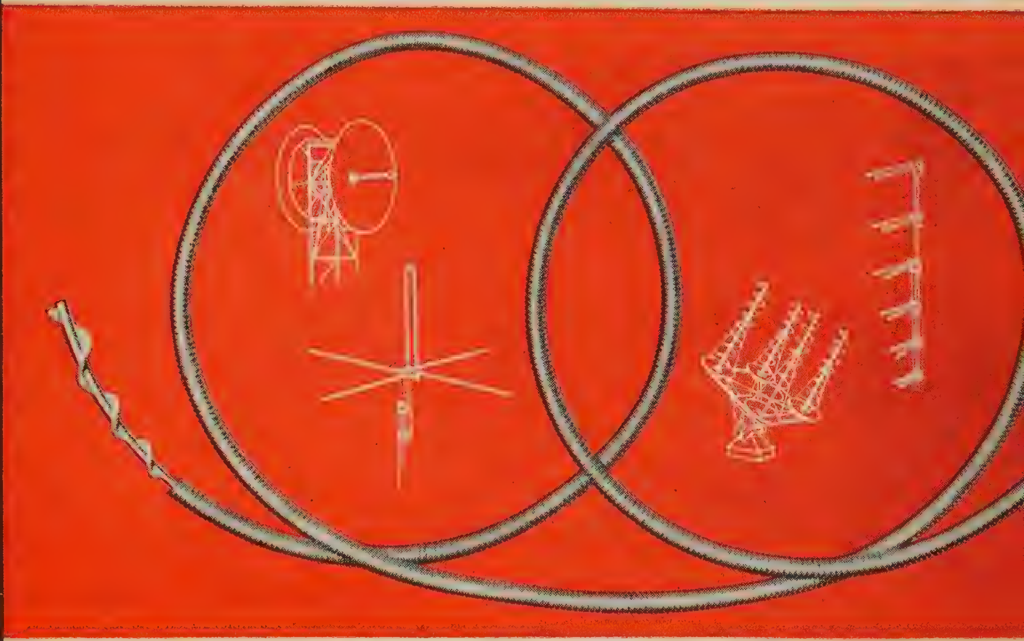
Corrugating outer conductor


Final cable assembly

HELIAX

THE FLEXIBLE AIR DIELECTRIC CABL

meets every communication requiremen



Easiest to install...longest to endure

Produced in the new ANDREW plant facilities, HELIAX is the flexible, low loss, low VSWR coaxial cable for use in all applications from VLF through microwave.

The production cycle in which the copper sheet stock is formed around the cable core, welded and corrugated on a continuous basis is depicted in the film strip. Rolled sheet stock provides considerably closer tolerance tubing than is possible by extrusion or other methods.

HELIAX is the *only flexible* air dielectric cable. This flexibility is imparted by the unique, continuous helical corrugated construction. Bending torque required is about one-half that required for straight wall aluminum or copper tubing of the same size.

HELIAX has the greatest resistance to crushing or kinking. Again this is due to its unique construction. Resistance to physical damage from crushing or kinking forces is about twice that of conventional aluminum or copper cables of comparable size.

HELIAX is the only U. S. produced a dielectric coaxial cable capable of bei manufactured in continuous lengths. Cri ical applications need no longer depend splicing 1,000 feet or shorter lengths make up a long cable run. HELIAX a fords the only splice free, trouble free a dielectric cable installation.

STANDARD SIZES AND TYPE NUMBERS

SIZE	IMPEDANCE	TYPE NO.
3/8	50	H3-50
7/8	50	H5-50
7/8	75	H5-75
7/8	100	HT5-100
1 5/8	50	H7-50
1 5/8	75	H7-75
1 5/8	100	H7-100
3 1/8	50	H2-50
3 1/8	75	H2-75

ANDREW is your *only* fully integrate source capable of the design and manufa ture of cable *and* fittings as well a antennas. ANDREW offers a wealth engineering experience in the field of R transmission devices.

You're invited to write for the ne HELIAX Catalog H.

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CORPORATION
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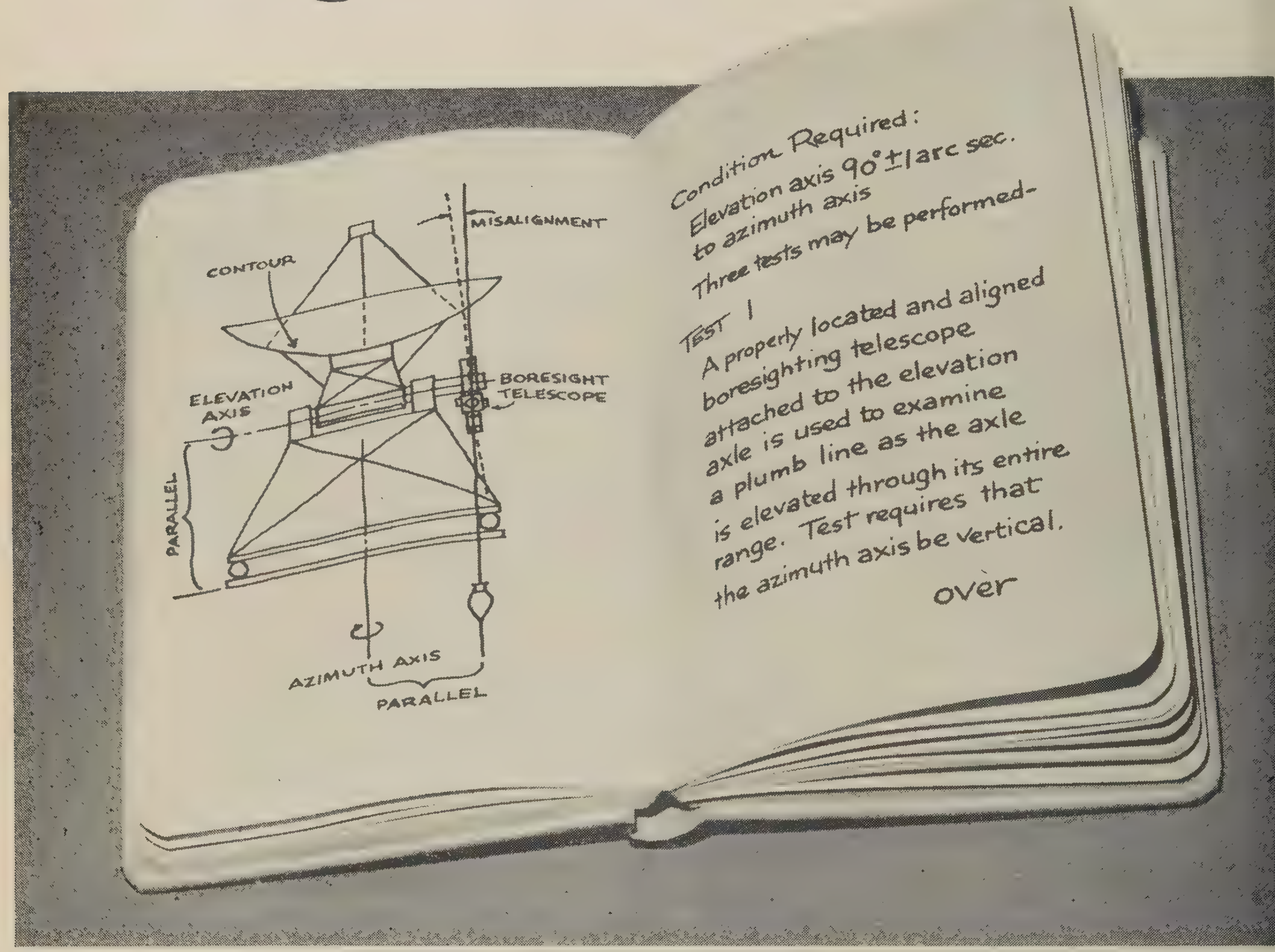
ANTENNAS • ANTENNA SYSTEMS • TRANSMISSION LINE

Circle Reader Service Card 4

Antenna Alignment: • RADAR • RADIO TELESCOP


MISALIGNMENT
CONTOUR
BORESIGHT TELESCOPE
ELEVATION AXIS
PARALLEL
AZIMUTH AXIS
PARALLEL

Condition Required:
Elevation axis 90°±1 arc sec.
to azimuth axis
Three tests may be performed-

TEST 1
A properly located and aligned boresighting telescope attached to the elevation axle is used to examine a plumb line as the axle is elevated through its entire range. Test requires that the azimuth axis be vertical.

over

Optical alignment has proved to be the only practical means of meeting the critical alignme tolerances currently required during the erection and operation of antenna systems.

Specific applications:

- Azimuth axis to pass through center of earth
- Elevation axis 90° to azimuth axis
- Line-of-sight boresighting telescope normal to elevation axis
- Electronic axis normal to elevation axis
- Dish geometry
- Feed horn location
- Antenna-to-antenna alignment

We welcome the opportunity to discuss your alignment requirements.

OPTICAL COMPONENTS: Prisms • Lenses • Mirrors • Coatings and Filters • Targets and Reticles • Graduations, angular and linear
ELECTRO-OPTICAL SYSTEMS: Angle Transducers • Auto Collimators • Photo-Electric Devices
OPTICAL SYSTEMS: Telescopes • Periscopes • Range-Finders • Collimators • Theodolites
OPTICAL TOOLING AND INDUSTRIAL ALIGNMENT EQUIPMENT
RADAR AND MISSILE ALIGNMENT SYSTEMS

OPTICS AND METROLOGY DIVISION

KEUFFEL & ESSER CO.
Hoboken, N. J.

Circle Reader Service Card 5

POWER AND PERFORMANCE:

then and now

In the days of Marius and Caesar, the Roman Standard symbolized military power and performance unmatched in its day: the might of Roman Legions.

Today, national defense frequently speaks its mind in quite a different symbology, the lexicon of waveguide. This language, widely spoken in defense and many other important segments of modern industry, incorporates a host of concepts of waveguide power and performance which originated at I-T-E. It is a fact that many such concepts and products for large waveguide, pioneered by us through the years have become "standard" thinking for industry.

For instance, you can now incorporate into your waveguide systems design I-T-E stock Waveguide components in sizes WR-770 and WR-2300. If lower VSWR, lower intermodulation effects, and rugged large waveguide interest you, send for I-T-E's Waveguide Catalog, now available.

I-T-E CIRCUIT BREAKER COMPANY
Special Products Division • 601 E. Erie Avenue • Philadelphia 34, Pa.

Circle Reader Service Card 6

A broad new dimension in slip ring capability!

Echo I whirling in space, creates a new dimension, sets a new pace in communications. Photo courtesy of NASA.

In keeping ahead of the rapid pace of the electronics industry, Gorham Electronics has given broad new dimension to its fabricated slip ring capability. A capability that ranges from the simplest to the most intricate circuitry and mechanical complexity. Typical products of this capability are 360 ring units with a multiplicity of low current, medium voltage, shielded and unshielded control circuits; high current motor and power circuits; high voltage, low current circuits as well as completely shielded microwave coaxial rings.

In-depth scientific and engineering brain power and the most modern assembly and test facilities combine to make Gorham Electronics your most up-to-date source for slip rings. If your interests include radar antennas, missile launching and airborne equipment, aircraft or helicopters, test equipment or guidance instrumentation, write for this new brochure!

Gorham
ELECTRONICS
• RESEARCH AND DEVELOPMENT
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Gorham
ELECTRONICS
DIVISION OF GORHAM MFG. CO.
PROVIDENCE 7, RHODE ISLAND

PB

PICKARD & BURNS, INC., SUBSIDIARY OF GORHAM MFG. CO., NEEDHAM 94, MASS.

Circle Reader Service Card 7

KING XERXES CAN SEDUCE *Lovely Princess*

By

DAVID ANDREWS

n the beginning, radar engineers built systems at three imeter and ten centimeter wavelengths. And they ed the three centimeter system X-band and the ten imeter system S-band. As the state of the art prosed, they worked up to 25,000 megacycles and down 00 megacycles. And they selected letters to designate icular frequencies within the bands. At first it was difficult to remember which letter designated which l, so they invented the mnemonic device which is the of this paper. The initial letters designate the frecy bands in order from 25,000 megacycles down to megacycles.

aturally this was all done to confuse the enemy. If he w your radar operated at 3600 megacycles, he could it immediately. But if his only information was that perated at S_g, he had to refer to the latest issue of his to-date Spy's Manual, and by that time it might be late. It didn't help him to use the same mnemonic because when translated into German, it became, önig Xerxes Kann Schőne Prinzessin Verfűhren." Bes the obvious difficulty of indicating two K-bands, it put P in the wrong place and indicated a V-band for low frequency end. Actually, V-band wasn't introed until after the war was over, and was then used to gnate frequencies around 50,000 megacycles, not 500.

hese radar systems used peculiar new-fangled hollow e for transmission lines, instead of coaxial or other mal lines. Nevertheless, by the time there were six dard sizes it was felt that they should be included in RG series for all transmission lines. The first 47 nbers had been assigned to coaxial lines and such, so six standard rectangular waveguides were designated -48 to RG-53, in order from 3 inches x 1 1/2 inches to inch x 1/4 inch. These were all brass waveguides.

ow it happened that a genius came along and showed silver waveguide for the 1/2 inch x 1/4 inch size no more than brass and had much less loss. Not to outdone, another genius showed that aluminum guide the 1 inch x 1/2 inch size was much lighter than brass had comparable electrical properties. Obviously these ld have been called "silver RG-53" and "aluminum -52," but that would be too simple, so "they" decided assign new numbers to these two. The numbers from -54 to RG-65 had already been assigned to more xial lines, so silver RG-53 became RG-66 and alumin RG-52 became RG-67.

Have I lost you yet? If you're still with me, you can see the mess coming up. RG numbers were assigned willy-nilly every time a waveguide was made "standard" in a new material. Interspersed with the waveguide numbers were those for other transmission lines. Any microwave engineer who could remember the assigned numbers was suspected of spending his time studying numbers and doing nothing else.

At this point the microwave components manufacturers came up with a solution. Since 1 inch x 1/2 inch waveguide was used in X-band, they called it X-band waveguide, regardless of the material used in making it. Similarly, 3 inch x 1 1/2 inch guide was called S-band guide, and 1/2 inch x 1/4 inch was called K-band guide. There are many manufacturers in this business. In fact, everyone seems to be in it at one time or another. Yet, almost without exception they have agreed upon these three designations, S, X, and K. But the mess is worse than ever. Each manufacturer chose his own designations for the rest of the waveguide sizes. Thus, two manufacturers use H to represent RG-49 while two others use it for RG-51. C is used for three different sizes, XB and R for two. RG-51 is designated H, W, XB, and XL by different manufacturers.

There is a ray of hope. The Electronics Industries Association has a new series of numbers for waveguides. It is sensible. (This shouldn't be too much of a drawback). Basically a rectangular guide is called WR followed by a number which indicates the hundredths of an inch in the wide dimension. Since the important dimensions of a waveguide are inside, this is the inside wide dimension. Thus, RG-52 becomes WR-90. This means: "Waveguide, Rectangular, 90/100 of an inch wide." WR-650 is 6.50″ wide inside. Obviously the system can be used to designate every new waveguide that comes along. WS would represent a square waveguide. But I still worry about round or ridged guides.

The major drawback of the WR numbers is that there is no way to differentiate between regular and half-height guides. But until something better comes along, it would be desirable to standardize on it so that all manufacturers speak the same language.

Of course, I have my own system, and naturally it's a panacea for all the ills of the old systems. I'm now working on a mnemonic aid to remember it. Let's see, "King Xerxes. . . . ."

7.5db Noise Figure

in

L, S or C BAND

J1 POWER
J2 I.F.
V2 417A
V1 417A
LEL INC
LOW NOISE
MIXER-PREAMPLIFIER
MODEL HML-2
FREQ. RANGE
1.0-2.0 KMC
INT. FREQ.
30 MC

MATCHED MIXER-PREAMPLIFIERS

(Waveguide units available for C, X and K bands)

TYPICAL SPECIFICATIONS

Noise Figure	7.5db typical
Bandwidth	8mc
Input Signal	Type "N" Coaxial
Minimum Overall Power Gain	25db
LO Power Requirement	1mw typical

For complete specifications and catalog write:

LEL INC. / Copiague, L. I., N. Y.

Industry News

DR. E. J. WHITMORE NAMED SYLVANIA MANAGE

Dr. E. John Whitmore has joined Sylvania Electric Produ Inc. as manager of development engineering at the Williamspo Pa. facilities of the company's Special Tube Operations, it been announced by Forrest E. Gehrke, manager of the facility.

In this position, Dr. Whitmore is responsible for tube resea and development activities, with emphasis on new devices in microwave and gas discharge fields. His activities complem related programs at the Mountain View, Cal., headquarters Special Tube Operations.

Dr. Whitmore was formerly chief engineer for the Canadi Marconi microwave tube plant in Montreal. Prior to that he w chief engineer of the Ferranti Vacuum Physics Laboratory Edinburgh, Scotland, where his research included duplexing vices, magnetrons, ceramic planars, small power tubes, gas atte ators, ferrites, rugged trigger triodes, and diodes.

In the early part of World War II, Dr. Whitmore served the research staff of Ferranti in Manchester, England, speciali in microwave receivers and signal generators. He received introduction to microwave tube engineering by acquiring techni responsibility for the wartime klystron and TR cell manufactur operations of Ferranti which commenced in 1942.

— mwj —

POLARAD ELECTRONICS NAMES ASSISTANT TO TH PRESIDENT

Appointment of A. H. Sonnenschein as Assistant to the President, has been announced by Dr. D. L. Jaffe, president of the Polarad Electronics Corp. Long Island City, N.Y. Mr. Sonnenschein, formerly Corporate Director of Planning, will also retain the duties of the latter position.

Sonnenschein joined Polarad's technical staff in 1951 as a project engineer and subsequently held the positions of Engineering Group Leader, Director of Engineering Operations and Chief Systems Engineer. He is graduate of the School of Technology at CCNY and of the Po technic Institute of Brooklyn.

He is a senior member of the Institute of Radio Engineers a a member of the American Management Association, Americ Institute of Electrical Engineers, American Ordnance Associati as well as Sigma Xi, Tau Beta Pi and Eta Kappa Nu, honor engineering societies.

— mwj —

NEW FIRM ESTABLISHED IN BALTIMORE

A new firm engaged in the design and manufacture of com nents for space satellites, missiles, radar communications, aer navigation and guidance controls has been established in Ba more, Md.

J. Kelsey Burr, 3rd, president of Applied Microwave El tronics, Inc., said design and development of several precis products is now underway and production will begin shortly.

Applied Microwave Electronics will specialize in precis microwave and electronic equipment and components.

The newly-formed Maryland corporation will build a n plant for its engineering and production operations in the Ba more area. Mr. Burr said completion of the new facility is pected in early 1961.

The firm's president is a former officer and director of F quency Standards, Inc., Asbury Park, N.J.

— mwj —

(Continued on page 16)

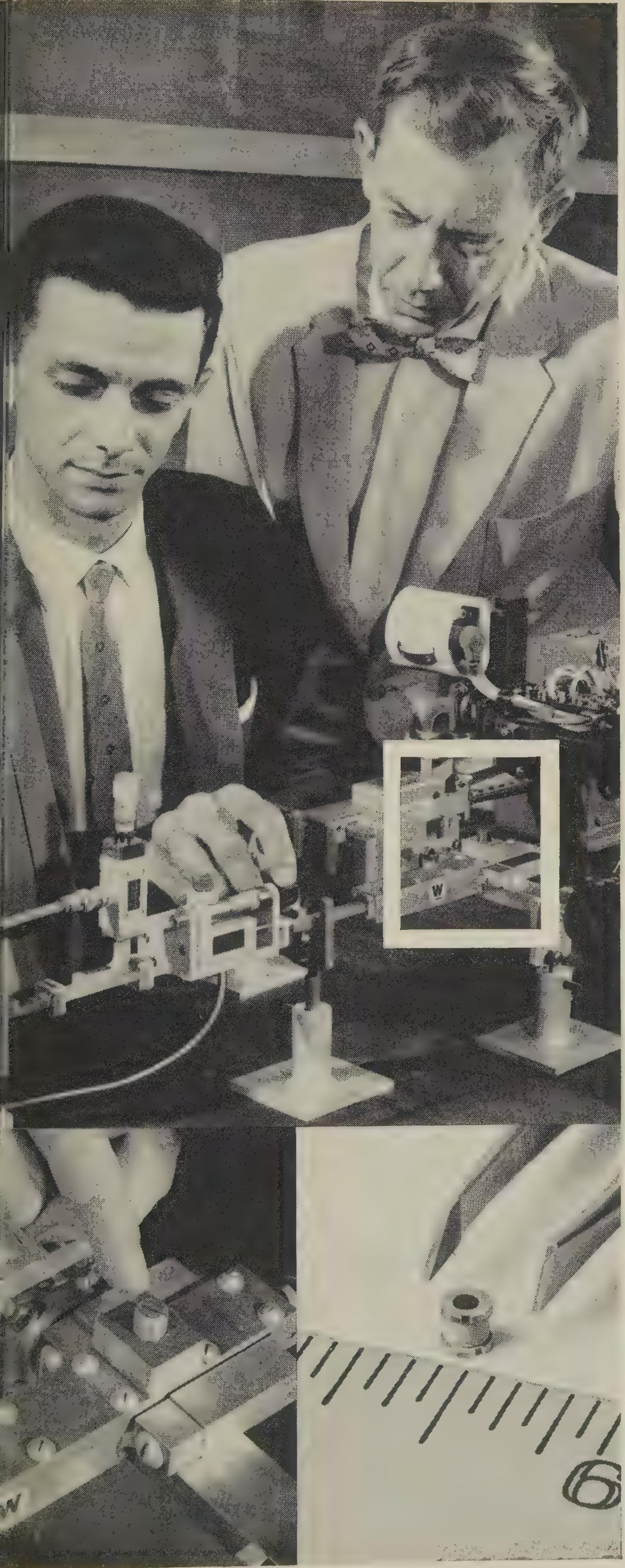


Photo: Courtesy Westinghouse Air Arm Division

Congratulations!

to WESTINGHOUSE for an exciting breakthrough.

A RADAR RECEIVER NOISE FIGURE of 2.8 db at an X-band operating frequency has been achieved by engineers of the Westinghouse Air Arm Division. Dr. Robert Rampolla (left), and Mr. Thomas Hollis (right), using a true non-degenerate X-band parametric amplifier and a Microwave Associates "pill" varactor (MA-4253), achieved a 20 db gain with excellent stability and ample bandwidth.

This remarkable accomplishment in low-noise amplification at X-band resulted from research on a program sponsored jointly by Westinghouse and the U. S. Navy.

Sophisticated Varactor technology at Microwave Associates which made these results possible has produced the most complete line available of advanced varactors in standard, miniature "pill", and glass packages.

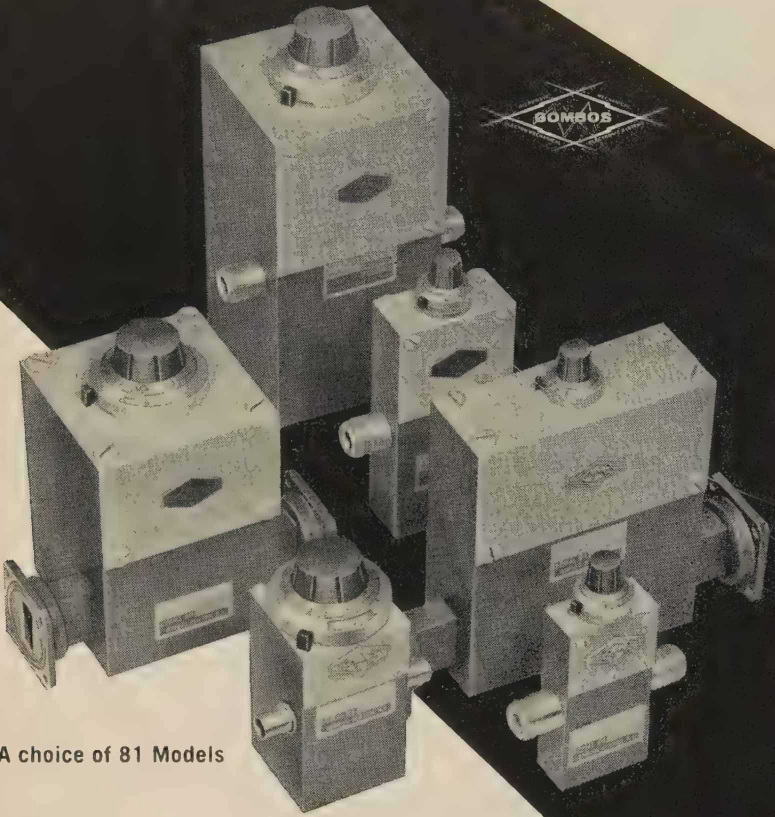
Write for detailed information and performance data on varactor techniques.

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASSACHUSETTS
Western Union FAX
TWX — Burlington, Mass. 942
Phone BRowning 2-3000

Circle Reader Service Card 9

TUNABLE BAND PASS FILTERS



A choice of 81 Models

A COMPLETE LINE FROM 500MC TO 18,000MC

Single knob tuning
2, 3, & 4 Section models offer a selection of rejection characteristics
Low insertion loss (1.0 D.B. Max.)
Coaxial or waveguide application

The John Gombos Co., Inc. line of TUNABLE MICROWAVE BAND-PASS FILTERS is designed for laboratory application such as Image Filters, Noise Measurements, Harmonic Rejection, Frequency Selection and Spectrum Analysis. These filters are also designed for systems applications such as Video or Superheterodyne Preselection, Resonant Diplexing, Frequency Discrimination, Multiplexing and Band Elimination.

JOHN
GOMBOS
CO., INC.
WEBRO ROAD, CLIFTON, N. J.

WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

(*Continued from page 14*)

THREE ENGINEERS ADDED AT HUGGINS

The addition of three engineers to t staff of Huggins Laboratories, Inc., Sunr vale, Cal., has been announced by R. Huggins, president and general manager

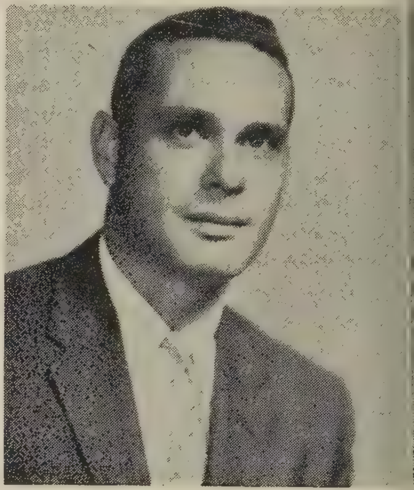
George C. Simmons, a graduate M.I.T., is working in the Research a Development Department, investigating t extension of the dynamic range of an band traveling-wave tube.

James C. McCraig, also assigned R & D, is concentrating his efforts in t area of low noise TWT. Mr. McCraig a graduate of the University of Kans and for two years worked with travelin wave tubes at the K.U. Electronic R search Laboratories.

Robert H. Johansen, now with the Pr ducts Development Department, is d veloping a new backward-wave oscillat He is a graduate of Northeastern Unive sity, and comes to Huggins from Ra theon Co.'s Spencer Laboratories, whe for two years he worked with backwar wave oscillators.

—mwj—

DOUGLAS MICROWAVE FORMS NEW RESEARCH AND DEVELOPMENT DIVISION



The Douglas Microwave Co., Inc Mount Vernon, N.Y., has announced th formation of a new division, Douglas R search Corp., to engage in research an development activities in the electron fields of microwave subsystems, antenna and major equipments.

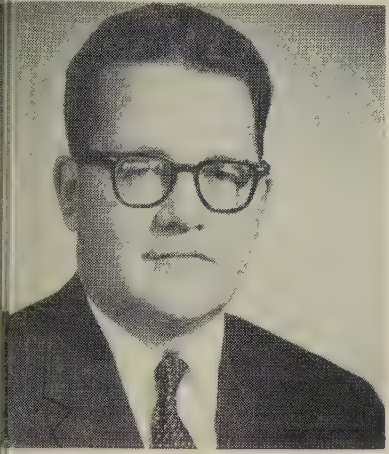
Henry Saltzman, formerly head of an tenna and microwave development at th G.P.L. division of General Precision, Inc Pleasantville, N.Y., has been elected pres ident of Douglas Research.

R. Harry Douglas, president of the pa ent company, said that the formation o the new division is part of a long rang plan to broaden his company's present ac tivities in the microwave field. The ne division will be located in quarters adja cent to Douglas Microwave's presen quarters in Mount Vernon.

Mr. Saltzman has been active in the de velopment of radar systems and RF su ms; as a physicist, he was engaged in ous areas of research at Yale Univer- and Dartmouth College while obtaining master's degree.

— *m w j* —

AYTHEON PROMOTES HANDLY



arl J. Handly has been promoted to newly-created post of division planning manager for Raytheon Co.'s Industrial nponents Division, Waltham, Mass. He been market planning manager for the sion since 1958.

andly will be responsible for coordinng the business planning activities of division's four operations: industrial , industrial cathode ray tube, receiving , and electro-mechanical components. division maintains plants and laboracs in Newton, Watertown and Quincy, ss.

oining Raytheon in 1944, Handly served various engineering and manufacturing sitions in the development of receiving industrial radio tubes until 1954 when was appointed product manager for gas radiac tubes. He held this post until was named market planning manager.

A graduate of the University of New mpshire, he continued his studies at ston University and Northeastern Unisity. He is a member of the Institute Radio Engineers, American Management sociation, American Marketing Associan, and is a licensed Professional Engir in Massachusetts.

— *m w j* —

RANTEC EXPANDS MARKET ACTIVITIES

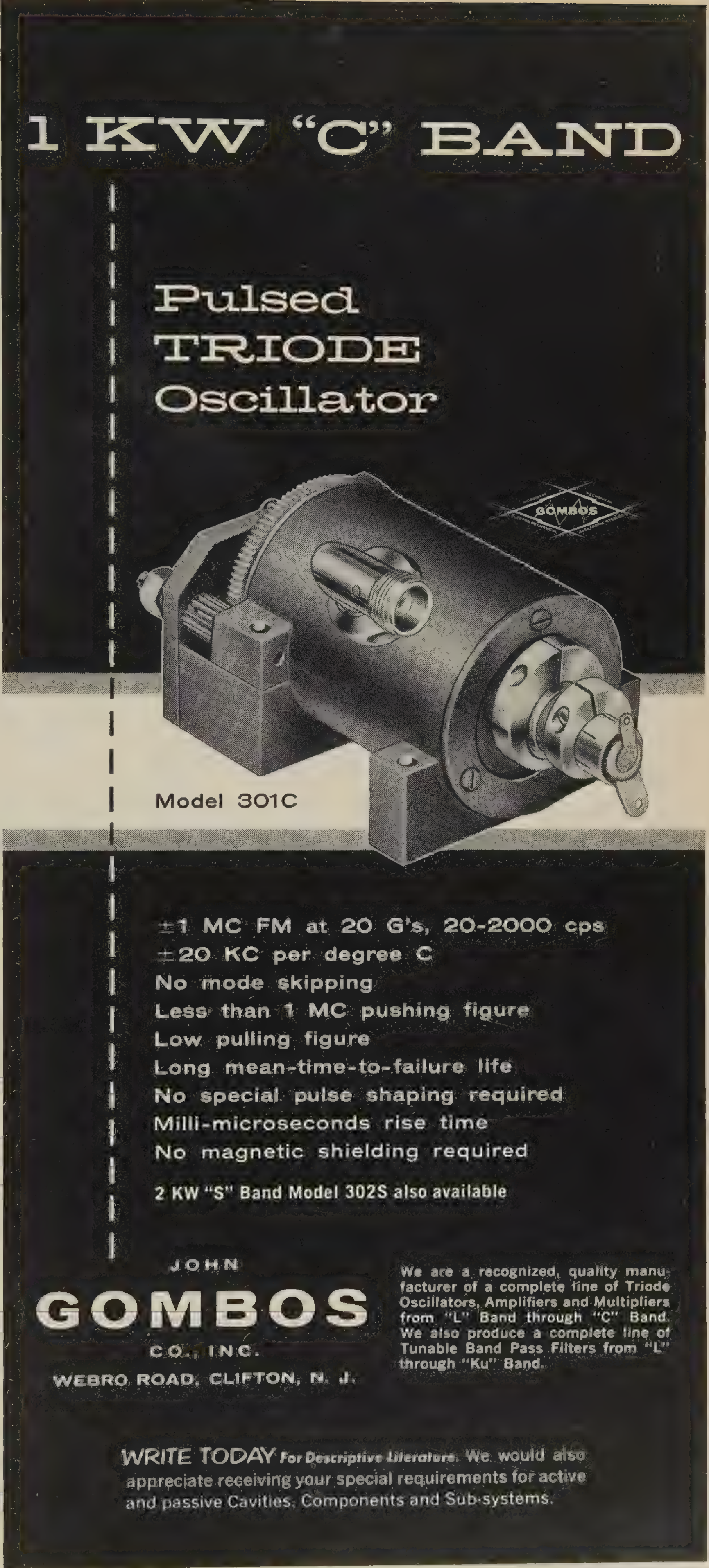
Rantec Corp., Calabasas, Cal., has exnded its marketing organization for the n's microwave products and engineering vices in both domestic and foreign sales eas, according to G. H. Singer, vice esident.

Foreign distribution to both Western rope and Japan will be handled by rminal Radio International, Ltd., N.Y. nadian representation with the exclusion British Columbia will be handled by len Crawford Associates, Ltd., Ontario.

Rantec has also appointed The J. E. Cua Co. to represent the corporation in mid-Atlantic states.

— *m w j* —

(*Continued on page 18*)


1 KW "C" BAND

Pulsed
TRIODE
Oscillator

Model 301C

±1 MC FM at 20 G's, 20-2000 cps
±20 KC per degree C
No mode skipping
Less than 1 MC pushing figure
Low pulling figure
Long mean-time-to-failure life
No special pulse shaping required
Milli-microseconds rise time
No magnetic shielding required

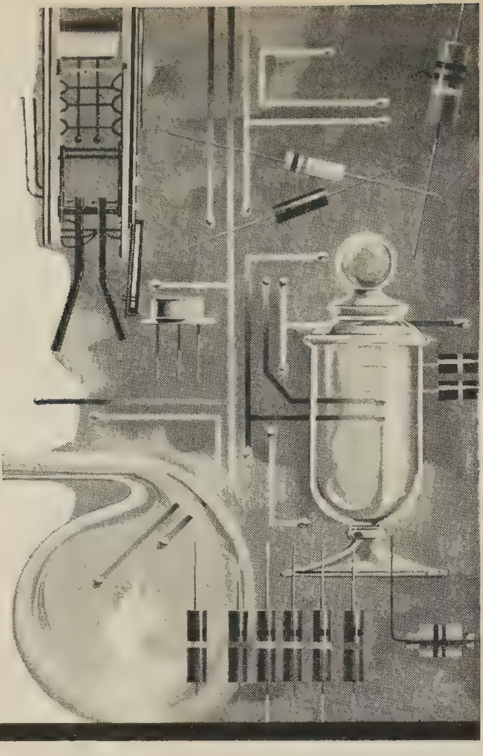
2 KW "S" Band Model 302S also available

JOHN
GOMBOS
CO., INC.
WEBRO ROAD, CLIFTON, N. J.

We are a recognized, quality manufacturer of a complete line of Triode Oscillators, Amplifiers and Multipliers from "L" Band through "C" Band. We also produce a complete line of Tunable Band Pass Filters from "L" through "Ku" Band.

WRITE TODAY *For Descriptive Literature.* We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

Production is up...costs are down on the high purity rare earths...



YTTRIUM OXIDE & GADOLINIUM OXIDE

...for advanced ceramic-electronic applications

At the Lindsay Division, Yttrium and Gadolinium salts are separated from rare earth concentrates by the ion exchange technique.

Lindsay rare earth chemicals offer a whole new spectrum of characteristics for the manufacture of ceramics and cermets which are stable at high temperatures and which exhibit well-defined electronic properties. Typical application—high purity Yttrium Oxide and Gadolinium Oxide, are being used as raw materials for yttrium-iron garnets in microwave circuit design. These, and other rare earths with intriguing electronic properties, are being studied for use as thermionic emitters, ceramic dielectrics, getters, and various potential semiconductor applications. Your consideration of these materials need not be hampered by cost, availability, or degree of purity. Lindsay Chemical Division, the leading source of rare earth chemicals, can supply your needs in commercial and highest purities, and in large or small quantities.

Write today for complete technical data.

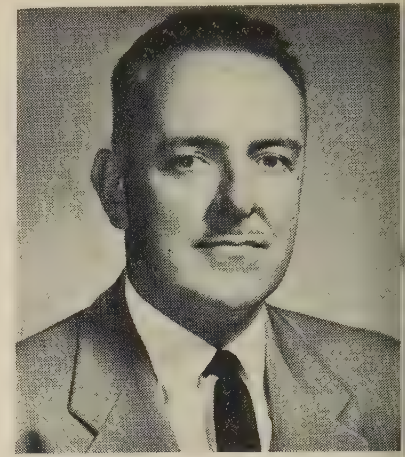
Lindsay Chemical Division
TRONA American Potash & Chemical Corporation
99 Park Avenue, New York 16, New York

Circle Reader Service Card 12

Industry News

(*Continued from page 17*)

EWING PROMOTED AT LENKUR



A. George Ewing, manufacturing m ager, has been named Vice Preside Manufacturing, and a director of Lenk Electric Co., Inc., San Carlos, Cal., telecommunications manufacturing subs ary of General Telephone & Electronics

His election as Vice President was nounced by Lenkurt President John Douglas. He had been elected to board by stockholders' action a few d earlier.

Ewing has been with Lenkurt si 1951 when he was employed as an dustrial engineer. Through subsequ promotions he has been manager of chanical engineering, manager of proc research and manager of production gineering. He was placed in charge all commercial product manufacturing the San Carlos plant in 1958.

Prior to joining Lenkurt, Ewing with Western Electric Co. for 15 years cluding four years as a field supervisor the installation division and a year loan to Pacific Telephone & Telegraph as an engineer.

—*mwj*—

MANSON AWARDED TWO NAV CONTRACTS

The Bureau of Ships Department the Navy, recently awarded two contra totalling more than $850,000, to Mans Laboratories, Inc., Stamford, Con manufacturer of specialized electro equipment. The two contracts cover search and development in the area high frequency synthesization and vanced high frequency communication

—*mwj*—

PRD TO STOCK ON WEST COAS

PRD Electronics, Inc., will stock the first time its precision microwave a electronic test equipment at its new W Coast facility in Inglewood, Cal.

Henry H. Michaels, Jr., president PRD, said that most PRD catalog struments will be stocked to provi California and Arizona customers sa ings and off-the-shelf delivery. Th new facility was needed to serve PRI

(*Continued on page 22*)

now 100 times greater average power

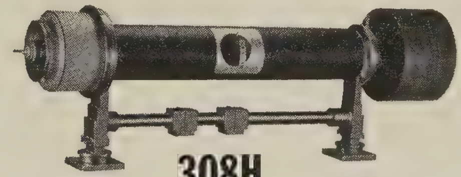
Now you can obtain traveling-wave tubes capable of 10 to 100 times the average power of conventional helix tubes. These X-band tubes are representative of a wide variety of the first commercially available all metal filter-type structures yielding both high gain and wide bandwidth. Their attractively small size and weight are made possible through application of the latest periodic focusing techniques.

Typical of these recent advances is the pictured 308H. For the first time a power traveling-wave tube is offered with a high-μ grid-controlled gun. This advantage, coupled with 53 db of saturation gain, provides exciting possibilities for the systems designer.

Consult with Hughes Microwave Tube Division if you have exacting design requirements of pulse rise time, phase shift sensitivity, bandwidth or power output. These qualities are yours in a light, compact, yet rugged package of all metal-ceramic construction. These advanced products can make your program a success. Orders are being accepted now for delivery in three or four months.

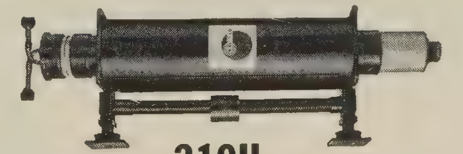
307H

LEFT: 100 kw peak power output (500 watt average), 8.5—9.5 kmc frequency range, 54 db saturation gain, 1% maximum duty cycle, beam voltage = 38 kv, 21 lbs. total weight of tube and magnet.



308H

Control grid $\mu = 55$. 15 kw peak power output (150 watt average), 8.6—9.9 kmc frequency range, 53 db saturation gain, 1% maximum duty cycle, beam voltage = 24 kv, 14 lbs. total weight of tube and magnet.



319H

20 kw peak power output (200 watt average), 8.4—9.6 kmc frequency range, 54 db saturation gain, 1% maximum duty cycle, beam voltage = 24 kv, 17 lbs. total weight of tube and magnet.

For full details on these and other equally outstanding tubes write or wire Hughes Microwave Tube Division, 11105 Anza Avenue, Los Angeles 45, California.

Creating a new world with ELECTRONICS

HUGHES

MICROWAVE TUBE DIVISION

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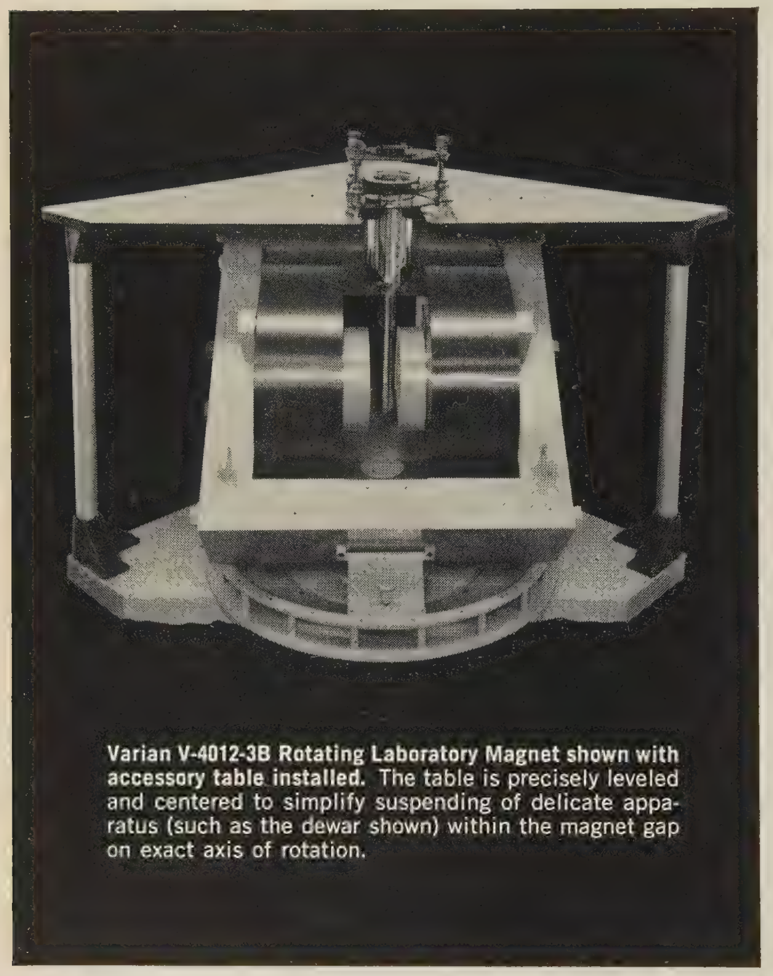
12-INCH PRECISION LABORATORY MAGNET

LARGE HOMOGENEOUS MAGNETIC FIELDS



Varian V-4012-3B Rotating Laboratory Magnet shown with accessory table installed. The table is precisely leveled and centered to simplify suspending of delicate apparatus (such as the dewar shown) within the magnet gap on exact axis of rotation.

Field homogeneity in a useful third dimension

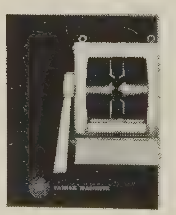
Presented here for the first time, a thre dimensional plot from a 12-inch Varia Magnet reveals over 100 cc of highly hom geneous field available to the experiment physicist. This volume is a technical accor plishment because field homogeneity no mally falls off rapidly with increasing ga width. It demonstrates again how Varian long experience puts extra value into the magnet systems.

Easy accommodation of bulky experimental apparatus

The large field shown is highly useful in tw respects. The over-all air gap width of near three inches is sufficient to hold glass dewa and other apparatus surrounding the fiel sensitive sample or object. And your samp itself may be of any bulk and dimensions u to those shown and still fall inside a fiel homogeneous within ±0.07 gauss of the 35 gauss central field strength. Outstanding pe formance is also attainable at other fiel strengths.

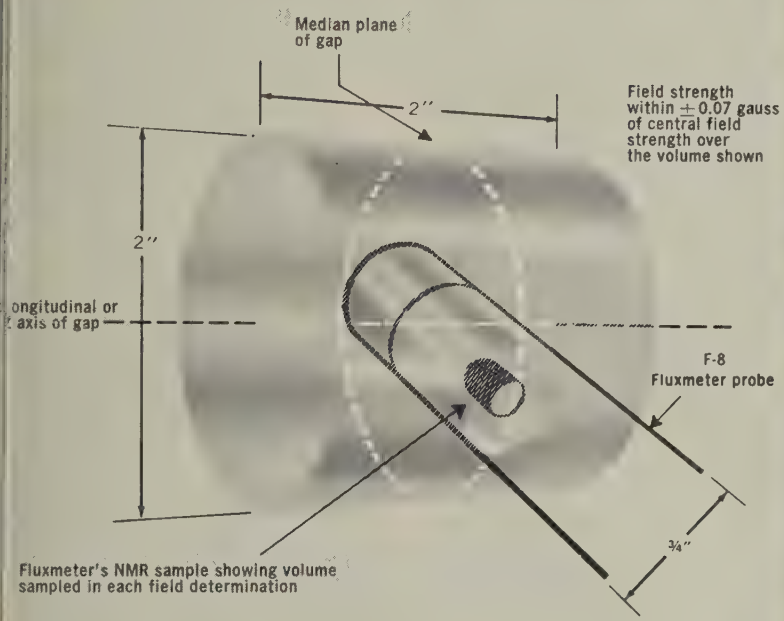
A versatile range of other capabilities

Much higher magnetic field strengths a available by purchase of additional pole ca configurations for smaller air gaps. The ext cost is nominal. And the magnet provides useful volume of homogeneous field at the higher strengths. Thus as a long-range inves ment a Varian Magnet is adaptable to nee unforeseen at time of purchase.



Write today for the new 32-page magnet brochure which gives specifications on Varian's full magnet line. Address Instrument Division.

N WIDE AIR GAPS


Median plane of gap
2″
Field strength within ± 0.07 gauss of central field strength over the volume shown
2″
ongitudinal or
axis of gap
F-8 Fluxmeter probe
¾″
Fluxmeter's NMR sample showing volume sampled in each field determination

More than 100 cc of homogeneous magnetic field within 3-inch central air gap. Three-dimensional cylindrical field of Varian 12-inch magnet shown full scale in oblique view; ring shim pole caps used; field strength 3550 gauss.

Probe extension cables to 100 feet in length available as accessory.

VARIAN F-8 FLUXMETER with new crystal frequency control. Time stability and accuracy enable the Varian Fluxmeter to make homogeneity field plots. The fluxmeter probe (at left) is shown extended into the magnet gap as actually done in making the field plot.

The F-8 can provide direct stabilization of magnetic fields by utilization of the D.C. error signal output. The F-8 is perfectly matched to the Varian 6- and 12-inch magnet system power supplies, and readily adapts to others.

VARIAN associates
PALO ALTO 34, CALIFORNIA

MR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS MAGNETOMETERS MICROWAVE TUBES MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

Circle Reader Service Card 14

6-pole, double-throw

MAKE THE MARK II RELAY WITH WEDGE ACTION THE STRONG LINK

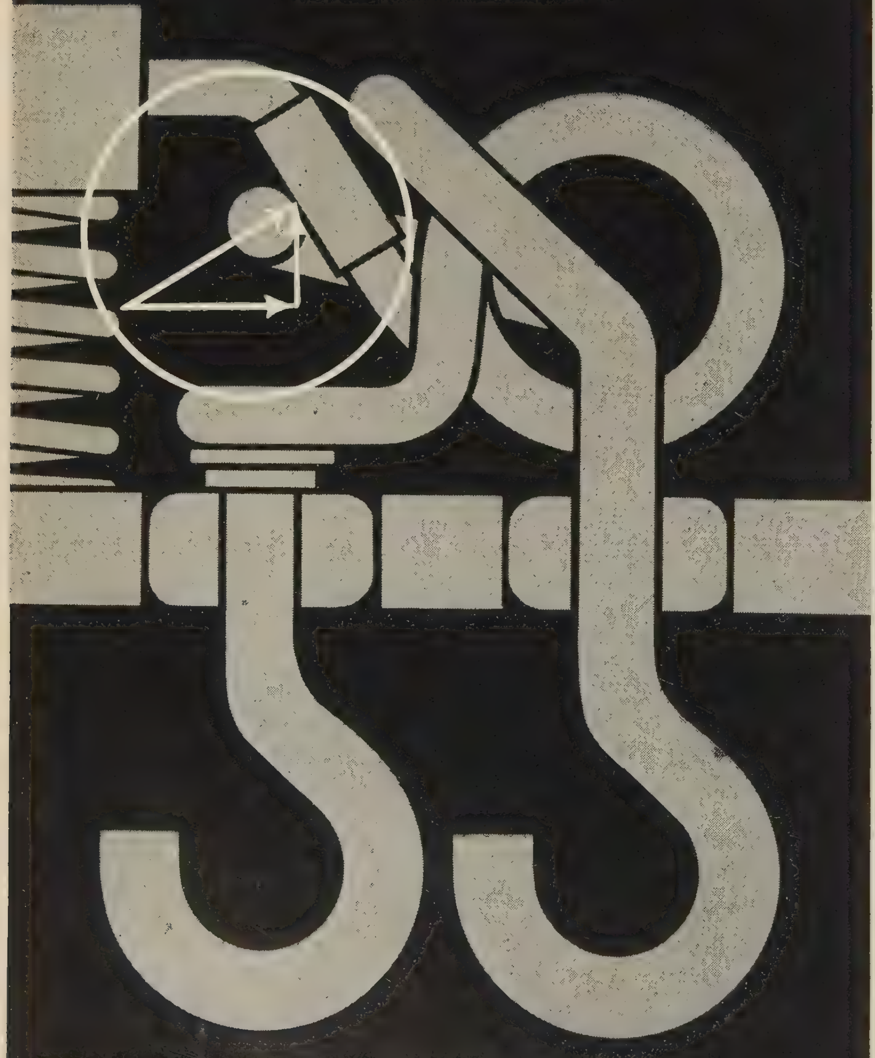
No longer must your design make allowances for unreliable relays. Use the Mark II relay with complete confidence. Shock it with 100 G'S . . . freeze it at −65°C or roast it at 200°C . . . give it 30 G'S vibration from 5 to 2000 cps. . . . or switch it from dry circuit levels to 2 amps.

The Mark II can take such punishment because of its exclusive contact action. The moving contact slides with a wedge action . . . it cleans itself . . . and the increasing pressure during overtravel virtually eliminates contact bounce, chatter and other relay headaches.

Make the relay the strong link in your system . . . specify the Mark II.

Literature now available.

ELECTRO-TEC CORP.
South Hackensack, N.J.
Blacksburg, Va.—Ormond Beach, Fla.



WEST COAST LICENSEE: PACIFIC SCIENTIFIC CO., P.O. BOX 22019, LOS ANGELES 22, CALIF.

PAT. NO. 2,866,046

Circle Reader Service Card 15

Industry News

(Continued from page 18)

expanding market in the microwave, el tronic, space, weapons, and missile ind tries, he said.

Applications engineers and other te nical personnel will be available to p vide assistance and faster service to t 13 western states.

—mwj—

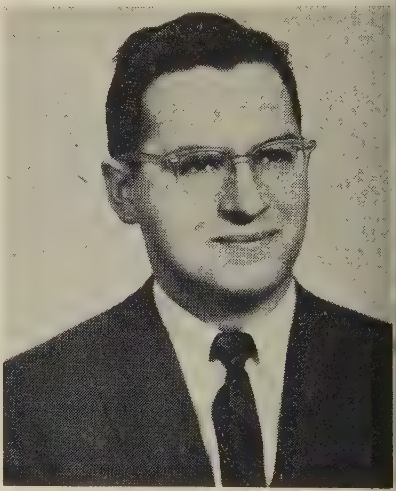
CONSTRUCTION BEGUN AT MICROLAB

Construction of a 15,000 square f addition has begun at Microlab, Livin ton, N.J., it was announced recently Harry A. Augenblick, president.

The new addition will essentially dou the manufacturing area of the compa bringing it to a total of 35,000 squ feet.

—mwj—

MOTOROLA MICROWAVE PROMOTES JONES



Motorola has promoted three members its microwave sales organization, accordi to Irving Koss, manager of the Chica firm's Microwave Department.

Richard G. Jones has been named M ager of Microwave Marketing. In his n position, he serves as national manager commercial microwave sales and sup vises all microwave marketing activiti His offices are in Chicago.

Jones, a 1950 graduate of M.I.T., join Motorola in 1956. He has been microwa sales manager for the 11 Western sta with headquarters in Burlingame, Cal.

His successor in the West Coast positi is Delbert G. Larson, former Motor microwave sales representative in the Pa fic Northwest. Larson, with the compa since 1951 and associated with its mic wave operations since 1954, gradua from the University of Kansas in 1944.

Also added to the Burlingame staff Robert L. Koehler in the newly crea post of Western district microwave spe alist. In his new job, he coordinates sale of microwave equipment to large

(Continued on page 24)

Greatest versatility!
• Highest accuracy!
• Widest range!

ARDA transistorized POWER METER

the narda microwave corporation
POWER MILLIWATTS
DECIBELS
BATTERY MINIMUM
BATTERY CHECK
CHARGING
POWER METER
NARDA MODEL 440

MODEL 440 **. . . $250**

at's most important to you in a power meter? Accu-? Portability? Independence from line voltage deviations? range? Stability? Rapid warm-up?

ot that you have to make a choice . . . or a compromise ny longer. The Narda Model 440 Power Meter gives you ese features! Completely transistorized and powered by ckel-cadmium battery, rechargeable during operation or night, it offers two low-power scales in addition to the standard scales (see below), a built-in charger with state-of-charge indicator and protection against overcharging, and freedom from internal heating caused by vacuum tubes.

Moreover, the 440 provides up to 18 ma bias current, enabling you to use the widest selection of bolometers and thermistors. In short, the 440 is the most versatile unit available to provide accurate direct-reading measurements of cw or pulsed-power automatically, over any frequency range for which there are bolometer or thermistor mounts. For complete data, contact your nearest Narda representative, or write us directly. Address: Dept. MJ-11

SPECIFICATIONS

POWER RANGES: 7 SCALES

1 mw full scale	–30 to –20dbm
3 mw full scale	–25 to –15dbm
mw full scale	–20 to –10dbm
mw full scale	–15 to –5dbm
mw full scale	–10 to 0dbm
mw full scale	–5 to +5dbm
mw full scale	0 to +10dbm

ma bolometers give best results on these scales.

Range Switch: 0.01 to 10 mw (full scale)

Accuracy: 3% of full scale reading

Bolometers & Thermistors: All 100 and 200 ohm, requiring up to 18 ma bias.

Battery Charger: Built-in; continuous or overnight. (Battery operable 16 hrs. before recharge required.)

the narda microwave corporation
118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

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MICROWAVE Kearfott PRODUCTS

COAXIAL BROAD BAND FERRITE ISOLATORS

IN SIZES FOR EVERY APPLICATION

Now—from Kearfott, a new and broader line of Ferrite Isolators to satisfy the most exacting requirements of band width and isolation. Combining low unit loss characteristics with compactness and light weight, this new series of Kearfott Coaxial Isolators is available from present stock. Immediate selection and faster delivery is assured . . . *precision performance proven.*

A FEW OF THE TYPICAL SPECIFICATIONS

MODEL	FREQUENCY	ISOLATION	INSERTION LOSS	VSWR
C991100-402	1.2—2.6 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.

GP

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

SALES OFFICES SEATTLE, WASH. VAN NUYS, CALIF. PHOENIX, ARIZ. DAYTON, OHIO CLIFTON, N.J.
PALO ALTO, CALIF. SAN DIEGO, CALIF. DALLAS, TEX. CHICAGO, ILL. WASHINGTON, D.C.

Industry News

(*Continued from page 22*)

dustrial, governmental and commercial ganizations. Koehler has been microw sales representative in the Arizona-Ut Nevada area. He has been with Motor since 1957.

—*mwj*—

COLUMBIA APPOINTS JACOBS NATIONAL SALES MANAGER

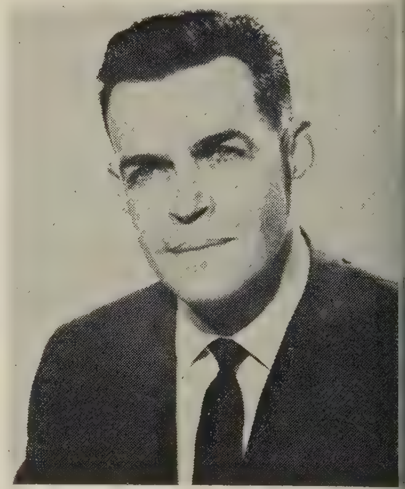
John C. Jacobs has been named head the sales program of Columbia Te nical Corp., Woodside, N.Y., manuf turers of electronic components, it was nounced by Dr. Nikit Ordjanian, pr dent of the company.

From 1956 to his new appointme Mr. Jacobs was the national sales mana for the Mount Vernon Division of Lit Industries. During this period sales r from one half million annually to over t million in the fiscal year ending July 1960.

From 1952 through 1956, he was gaged as products engineer and compone engineer on airborne radar systems w General Precision Lab, Inc. From 19 when he received a BS degree in Electri Engineering from Manhattan Colle through 1952, Mr. Jacobs was engaged non-military work with IBM.

—*mwj*—

GAILEY NAMED CONTRACT ADMINISTRATOR AT FXR



Platon G. Gailey has joined FXR, I Woodside, N.Y.. manufacturer of mic wave test instrument and associated equ ment, as administrator for all commer and government contracts, William Marshall, vice president for sales marketing, announced.

"Mr. Gailey has a broad backgrou acquired during 14 years with West Electric Co. in contract negotiations, p chasing and price redetermination cov ing major electro-mechanical compone for defense systems," Mr. Marshall said

Mr. Gailey, who was a combat pilot World War II, received a B.S. deg from the University of Virginia in 19

—*mwj*—

(*Continued on page 26*)

PRD *previews/reviews/design notes*

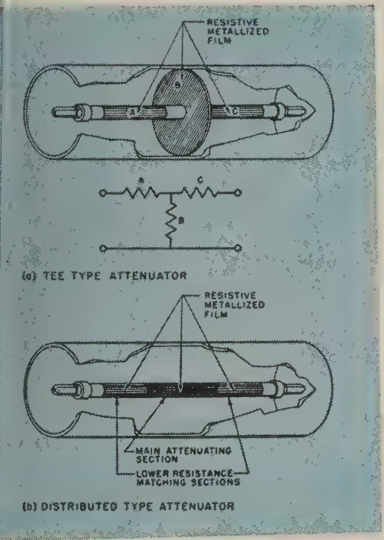
Design Considerations of Attenuators

end use of an attenuator—whether
standard in power or attenuation
urements, a power or signal level
ster, an isolator or buffer pad—
of course, bear on its design. But
in design and construction needs
remain constant. Here are some of
considerations that go into a PRD
uator.

Attenuating Elements

ave found that metallized glass or
nic generally make the best resis-
elements. They are smooth, chemi-
inert, non-hygroscopic, and will
warp or change shape. We apply an
mely thin metal film to the element
o ways: by "paint" coating and
ig, and by high vacuum deposition.
baked-on film method proves best
oaxial attenuators, and the vacuum
sition preferable for waveguide.

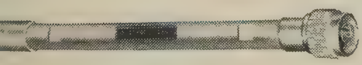
Fixed Coaxial Attenuators


RESISTIVE METALLIZED FILM
B
A
C
A
C
B
RESISTIVE METALLIZED FILM
MAIN ATTENUATING SECTION
LOWER RESISTANCE MATCHING SECTIONS

(a) TEE TYPE ATTENUATOR

(b) DISTRIBUTED TYPE ATTENUATOR

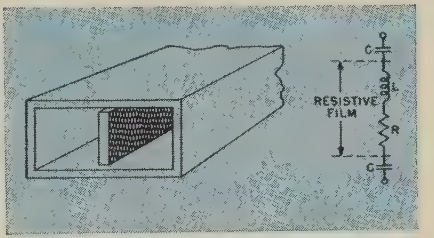
PRD 1100



PRD 130

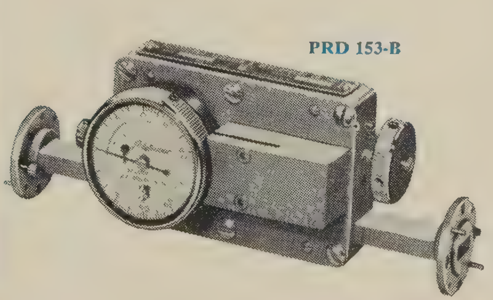
e two basic types of coaxial attenua-
s produced by PRD are shown
ve, in schematic drawing and photographs. The first, represented by the PRD 1100, uses one or more T sections with lumped resistive elements. The distributed type, illustrated by the PRD 130, uses an inner conductor of an electrically long resistive film. The T section PRD 1100 operates best at low frequencies, from dc to 4 KMC; the PRD 130 ranges from 2 to 10 KMC. Both dissipate one watt and are calibrated to ±0.2 db accuracy. The PRD 130 can attenuate up to 20 db; PRD 1100 up to 10 db.

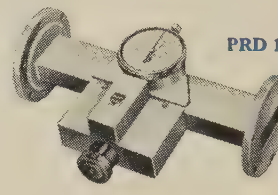
Waveguide Attenuators



The drawing above gives a schematic presentation, with equivalent circuit, of a resistive film parallel to the electric lines in a waveguide. Attenuation is varied by moving the metal-coated glass panel in two usual ways: (1) by lowering it into the waveguide through a slot, as in the PRD 153-B, known as a "flap" type (Freq. range 18.0 to 26.5 KMC; Attenuation to 35 db; Max. VSWR 1.10; Max. insertion loss 0.5 db; Calibration accuracy ±0.2); or (2) by moving the lossy element from the side wall toward the center of the waveguide ...known as the "vane" technique, and illustrated by PRD 178-B (Freq. range 5.4 to 7.2 KMC; Attenuation to 45 db; Max. VSWR 1.15; Max. insertion loss 0.5 db; Accuracy to ± 0.2).

PRD 153-B





PRD 178

Another version of the vane method of attenuation is exemplified by our level set attenuators, such as the PRD 171-B (Freq. range 2.6 to 3.95 KMC; Max. attenuation to 40 db; Max. VSWR 1.15).

PRD 171-B

These are only a few of more than one hundred attenuators produced by PRD and a brief review of the broad design principles involved. For more specifications on these and other units, write for the PRD Attenuator brochure. For design information, write our Applications Engineering Department.

We have many interesting openings for engineers...contact Mr. John R. Zabka

PRD
ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly, Polytechnic Research & Development Co., Inc.

202 Tillary Street, Brooklyn 1, N. Y.
ULster 2-6800
1608 Centinela Ave., Inglewood, Cal.
ORegon 8-6922

HARRIS
INTERTYPE
CORPORATION

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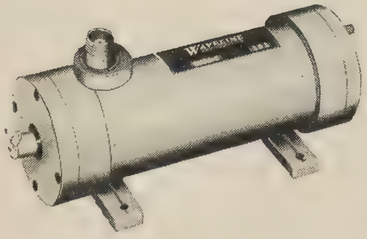
WAVELINE

COAXIAL CAVITIES

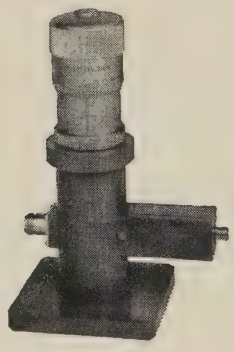
TRIODE OSCILLATORS



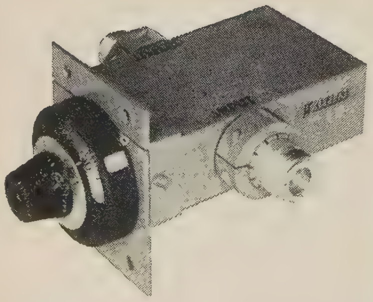
- Available in S and C bands.
- Unique tuning adjustment.
- Temperature compensated.
- Rugged mechanical design.

WAVEMETERS

- Four models available to cover 2300 to 8200 mc/s.
- Accuracy .02%.
- High unloaded Q.
- Accessory crystal current meter available.



TUNABLE FILTERS



- Multi-cavity ganged or individually tuned.
- Minimum insertion loss.
- Covering 2000 to 6000 mc/s.
- Standard models available.

WAVELINE INC.

CALDWELL, NEW JERSEY

Phone CApital 6-9100

TWX Caldwell, N. J. 703

Industry News

(*Continued from page 24*)

1961 NATIONAL SYMPOSIUM MICROWAVE THEORY & TECHNIQUES CALL FOR PAPERS

Once again an invitation is extended
scientists and engineers to submit pa
for the 1961 National Symposium of
Professional Group on Microwave Th
and Techniques.

As indicated in the initial Call
Papers, the Symposium will take place
May 15, 16 and 17 at the Sheraton
Hotel in Washington, D. C. The Techr
Program Committee for the Symposiur
seeking original, contributed papers in
fields of microwave research, developn
and applications, particularly those of
rent and major interest.

Five hundred word summaries of
posed papers should be submitted as
as possible but not later than Decen
12, 1960 to: Gustave Shapiro, Chairn
Technical Program Committee, Enginee
Electronics Section, National Bureau
Standards, Washington 25, D. C.

Arrangements will be made for
publication of the selected papers in
Symposium issue of the PGMTT Tr
actions.

—*mwj*—

MICROWAVE EXHIBIT TO BE HELD AT THREE LOCATIONS

Sponsored by CDB Enterprises, I
Hicksville, L. I., N. Y., manufactu
representatives, the second annual Mi
wave Symposium and Equipment Exh
will be held at three locations — in
Metropolitan New York and Long Isl
area, in the Northern New Jersey a
and in the Philadelphia-Camden area
from November 30 through Decembe

Dates and places are:

Wednesday and Thursday, Novem
30 and December 1, Sagamore Ro
Roosevelt Field, Garden City, L. I., N.

Monday and Tuesday, December 5
6, Oxford-Cambridge Room, Essex Ho
Newark, New Jersey.

Thursday and Friday, December 8
9, Keystone Room, Cherry Hill I
Haddonfield, New Jersey.

The exhibits will be open from n
to 10 p.m. Technical papers will be p
sented each night from 7 p.m. to 10 p
by leading engineers from Antlab, G
ham Electronics, Burmac Electron
Fenwal Electronics, METCOM, Mi
wave Electronics Corporation, and P
Electronics.

—*mwj*—

TRAK ANNOUNCES FORMATION OF NEW SUBSIDIARY

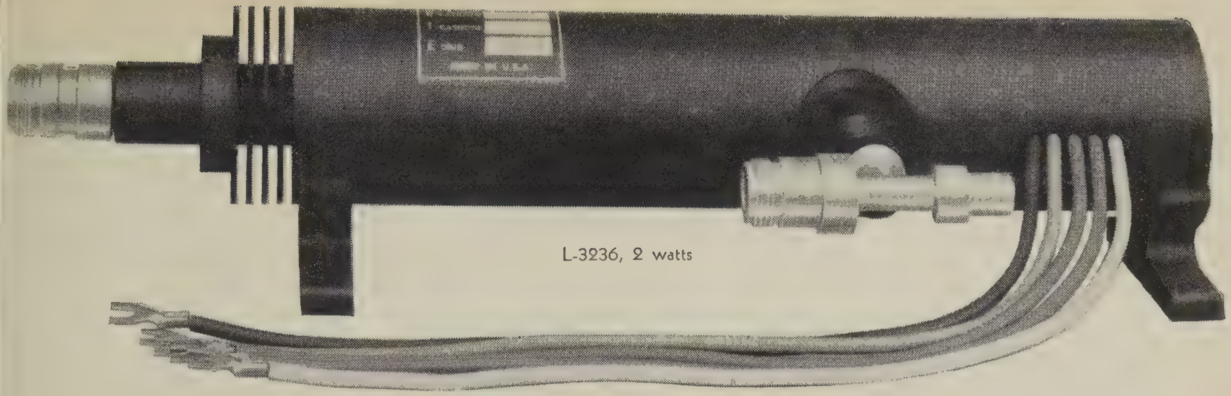
Trak Electronics Co., Wilton, Co
announces the formation of a new s
sidiary, Trak Microwave Corp., Tam
Fla.

Trak Microwave Corp. will begin op
ation in its new Tampa plant on October

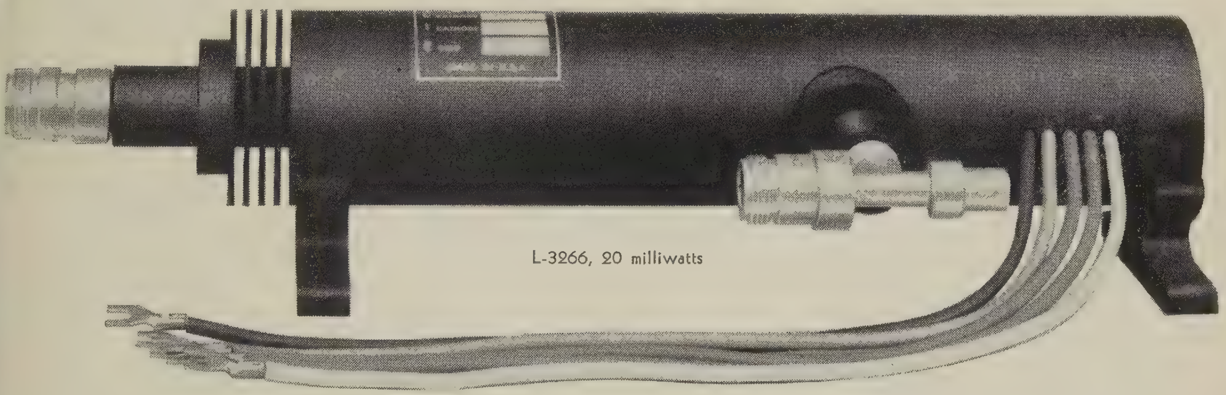
Trak Microwave Corp. will provide
developmental research facility for tri
cavities in RF signal generation from 5

(*Continued on page 30*)

Circle Reader Service Card 19


L-3236, 2 watts

TWTWINS


L-3266, 20 milliwatts

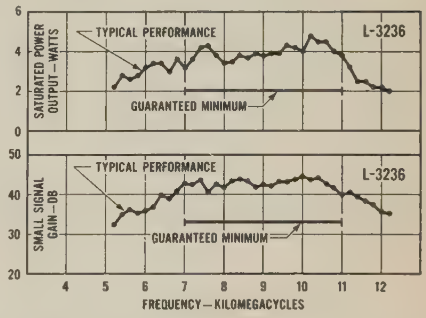
ese Litton TWT twins are PPM
cussed X-band traveling wave
bes. They are *not* prototypes. They
e metal and ceramic tubes in field
plication *now*.

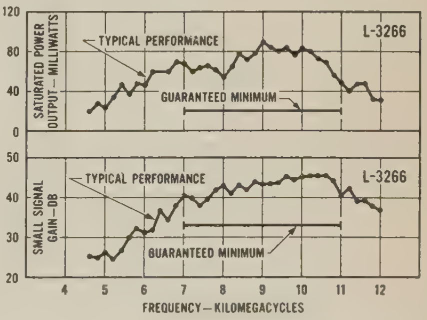
esigned to cover X-band with
inimum saturated CW power of 20
illiwatts (L-3266) and 2 watts
-3236), they may be operated in
scade to amplify signals as small as
50 dbm to the 2 watt level. Their
rformance, far exceeding the con-
rvative specifications, is evident in
e accompanying graphs.

nall size (less than 12″ in length),
ht weight (under 4 pounds each),
d extreme environmental capabil-
y (temperature compensated
54°C to 86°C) make these tubes
e ideal choice for military applica-

tions. A typical airborne equipment, designed and manufactured by Granger Associates of Palo Alto, California, incorporates the L-3266 and L-3236 and occupies only 0.75 cubic feet, including all necessary power supplies, modulating circuitry, cooling, etc. This equipment is now in field operation.

If your work involves ECM repeaters, radar target enhancement, frequency diversity radar or any application requiring broadband microwave amplifiers, appraise these new tubes. In production quantities their price is the lowest in the field. Ask for catalog sheets on the L-3266 and L-3236. Address: Litton Industries Electron Tube Division, 960 Industrial Road, San Carlos, California.

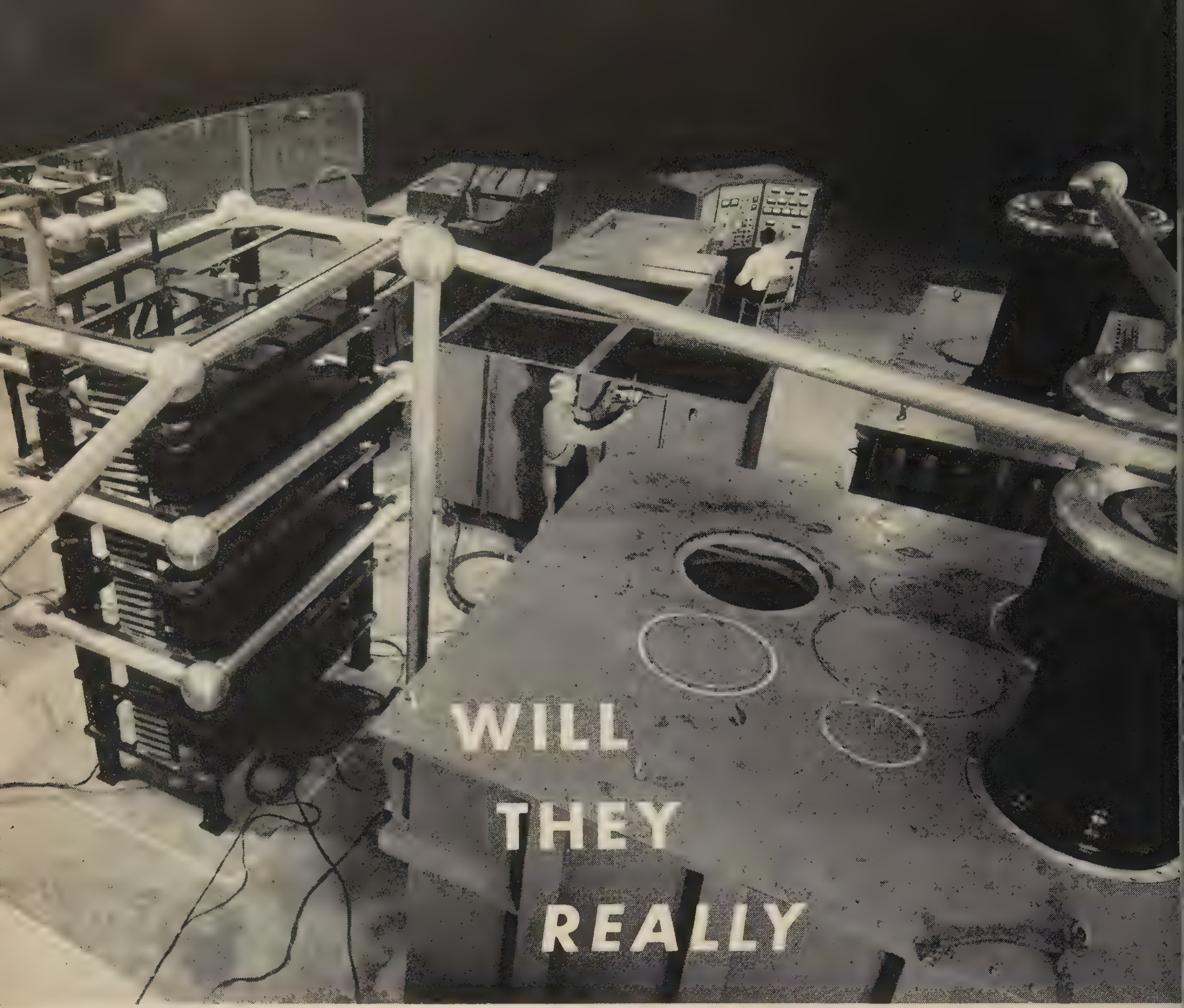




LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

"Capability that can change your planning"

Circle Reader Service Card 20



HAVE TO REWIRE PALO ALTO?

Here at Levinthal, just nine of the jobs currently in the plant, if all turned on at once, would pull 10 megawatts of average power from the a-c mains, enough for a small city. But don't worry, there's plenty of power in the West.

Shown in the picture is the fourth largest of the nine, a microwave-tube-test power supply and modulator for modulating-anode klystrons. Designed and built by Levinthal, it includes a number of advanced features for flexibility and safety.

Perhaps your problems include one requiring high powers with engineering and production pushing the state of the art. If so, Bob Johnson, our application-engineering manager, is the man to discuss your needs.

LEVINTHAL ELECTRONIC PRODUCTS

STANFORD INDUSTRIAL PARK PALO ALTO 7, CALIFORNIA

SUBSIDIARY OF
RADIATION
INCORPORATED

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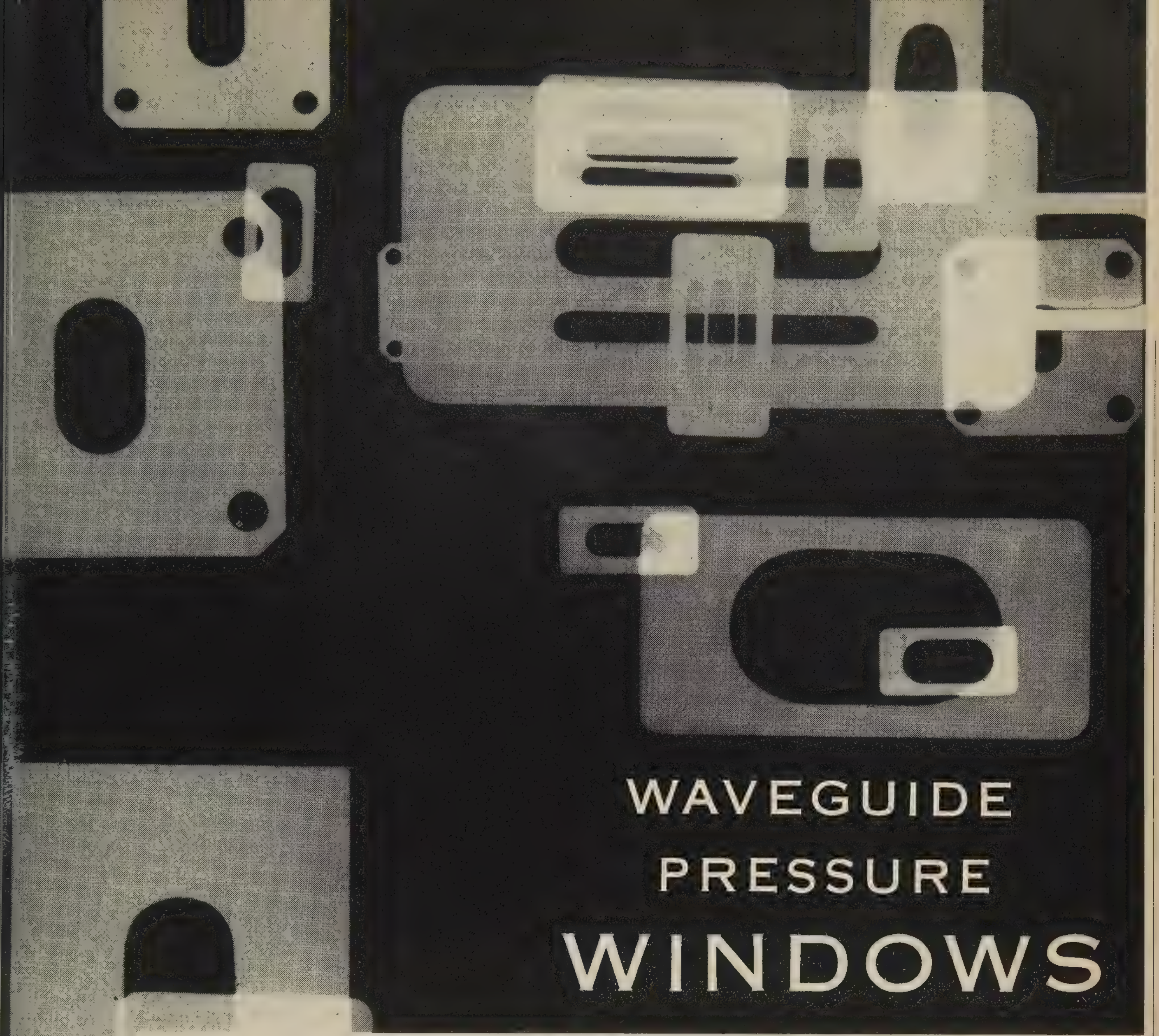


WAVEGUIDE PRESSURE WINDOWS

Contact MDL first for reliable stock-design microwave pressurizing windows — either flange-mounting or solder-mounting types. Available in a wide range of frequencies and configurations, MDL windows are fully tested and guaranteed. As the leading designer and manufacturer of precision microwave components, MDL assures you fast delivery at low prices — plus experience-tested design reliability and performance. MDL will also be pleased to work with you to meet your requirements for special windows. Write for technical literature.

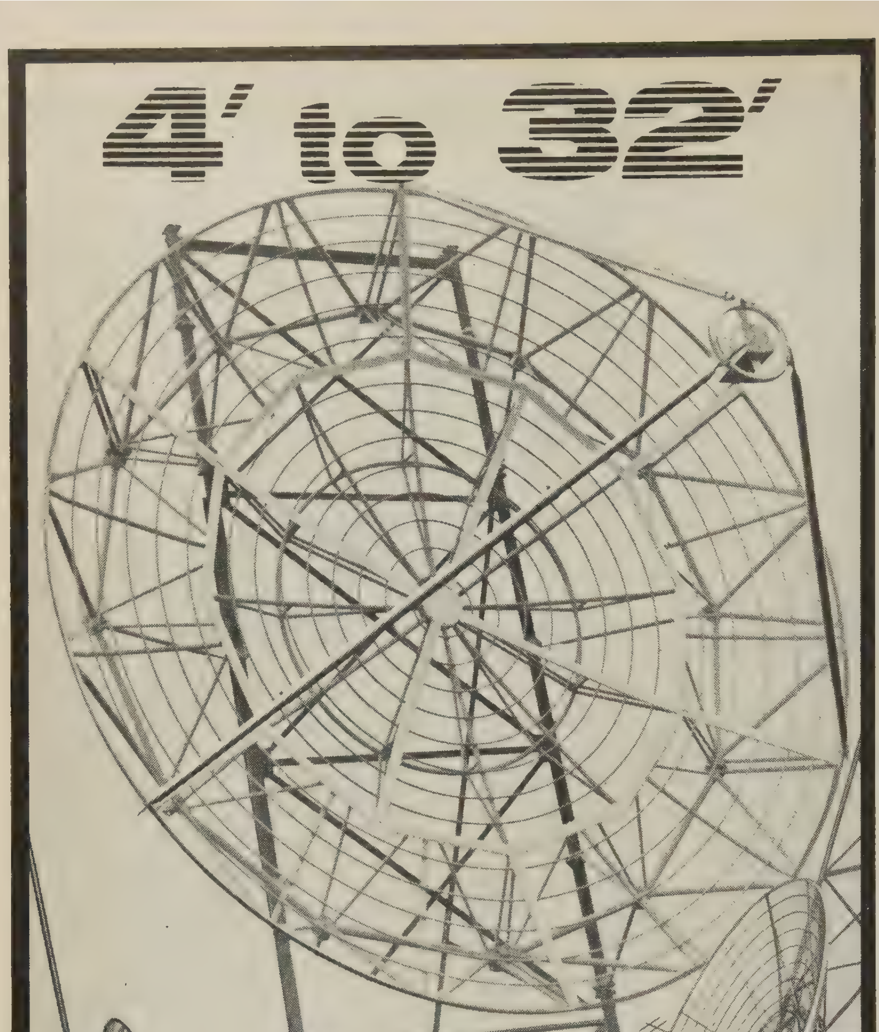
Circle Reader Service Card 22

MDL WAVEGUIDE PRESSURE WINDOWS

For use with EIA WR ( ) Waveguide Size	Center Frequency (kmc)	Frequency Range (kmc)	Max. VSWR Band Edges	Peak Power (kw)	Max. Pressure (psig)*	MDL Model No.
SOLDERABLE WINDOWS						
90	9.0	8.4 – 9.6	1.25	150	30/20	90WD56D
90	9.31	9.0 – 9.6	1.25	100	60/30	90WD86D
90	9.6	8.2 –11.0	1.15	200	60/30	90WD116D
90	8.4	8.2 – 8.6	1.20	50	45/30	90WD216D
112	9.8	8.6 –10.6	1.15	320	45/20	112WD26D
187	5.7	5.5 – 5.9	1.10	100	45/30	187WD26D
284	2.80	2.75– 2.85	1.20	170	60/45	284WD16D
FLANGE WINDOWS (mount between two choke flanges)						
42	21.0	18.0 –24.0	1.25	70	45/30	42WF16D
90	9.8	8.2 –12.4	1.25	300	30/20	90WF56D
112	9.0	7.5 –10.6	1.15	320	60/30	112WF26D

Ambient temperature range —55°C to +100°C. All finishes silver plate
*Higher number indicates pressure on glassed side of window.

Microwave Development Laboratories, Incorporated
92 Broad Street, Babson Park 57, Wellesley, Mass. Tel: CE 5-6252



PARABOLIC ANTENNAS

TACO DEVELOPMENTAL FACILITIES
Taco owns and operates one of the most advanced antenna laboratories in the world. Free-space test sites, completely equipped with the latest instrumentation are currently probing the frontiers of advanced antenna designs . . .

A standard line of parabolic reflectors designed to provide high electrical and mechanical efficiency, simple installation, and a high degree of mounting and driving versatility. Also, Taco offers a standard line of drivers for single, dual, and circular polarization, as well as design services for development of custom drivers for beyond-the-usual requirements.

WRITE FOR COMPLETE TACO CATALOG ON PARABOLICS, HELICALS, RUGGEDIZED YAGIS, AIRBORNE AND OTHER ANTENNA DESIGNS . . .

TACO
SHERBURNE, NEW YORK

Circle Reader Service Card 23

Industry News

(*Continued from page 26*)

mc upwards. Their present line include seven new oscillator cavities announce during 1960, which were the outgrowth o the first Trak S-band cavity built in 1949 These cavities are for applications in gri pulse, plate pulse and CW service. It i expected that an X-band triode oscillato will be announced shortly, and microwav harmonic generators also will be built.

—*mwj*—

MICROWAVE DYNAMICS FORME AS SUBSIDIARY OF TALLEY INDUSTRIES

A microwave systems and componen company, Microwave Dynamics Corp., h been formed in Industrial Park, Lor Island and will operate as a subsidiary Talley Industries, Inc., of Cheshire, Conn parent company of four engineering an manufacturing corporations.

Microwave Dynamics is located in new 17,000 sq. ft. plant. Facilities for r search, development, manufacturing an administration are being installed, an operations officially began on Septemb 12th. According to Neal Deoul, preside of Microwave Dynamics Corporation an former general sales and marketing ma ager of FXR, Inc., Woodside, N.Y., th new company will maintain its own e perimental model shop and productio facilities, thus functioning as both a r search and a manufacturing organizatio

Microwave Dynamics plans to develo and produce microwave systems, sub-sy tems, test equipment instrumentation an components. These are employed in n tional defense radar and communicatio networks, as well as in space program satellite and industrial communication telemetering, missile guidance and therm nuclear research.

Specifically, the company is specializin in the development of such electronic d vices as laboratory test equipment, i cluding signal generators, receivers an spectrum analyzers, as well as in develo ment and production of high power pul

(*Continued on page 33*)

DIODES Designed as ectifiers, EG&G's high-ower, high-voltage iodes can be used as old-off diodes, inverse lippers and backswing lippers. Compact, lightweight and rugged, they re built to withstand evere shock, vibration nd high temperatures.

THIS IS THE FIRST COMPLETE LINE OF CERAMIC-METAL, HYDROGEN-FILLED TUBES ever made available to the industry

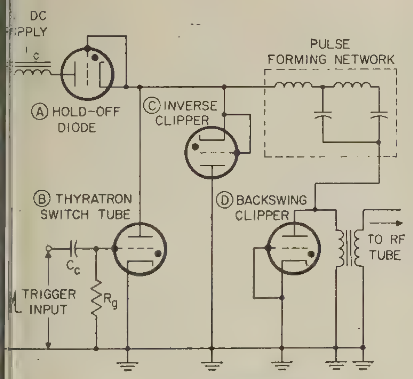
Now, for the first time, design engineers have at their disposal a *complete* line of miniaturized, hydrogen-filled tubes, which will meet most radar circuit requirements and permit the design of truly compact modulator packages.

TENTATIVE RATING CHART

	CLIPPER DIODE RATINGS				RECTIFIER RATINGS			HEATER				CATHODE & RESERVOIR WARM-UP TIME	DIMENSIONS		WT.
PE	epx kv	ib a	Ib Adc	Ip Aac	epx kv	ib a	Ib Adc	Ef Vac	If Iac max.	Eres Vac	Ires Iac max.	minutes	Max. Height-inches	Max. Dia.-inches	lbs.
-2	8.0	9.0	.100	2.0	8.0	1.5	0.25	6.3	3.2	*	*	0.5	2-1/2	1-1/5	0.13
R-1	25.0	250	.125	4.0	20.0	9.0	1.5	5.0	9.5	5.0	3.5	5	4-5/8	2-5/16	0.95
-3	25.0	500	.500	16.0	25.0	30.0	5.0	6.3	13.0	6.3	4.0	10	5-3/4	3-3/8	2.07

LS: *Reservoir connected internally across cathode-heater. Temperature range —55°C to +125°C ambient; 400°C envelope max.

TYPICAL MODULATOR APPLICATION

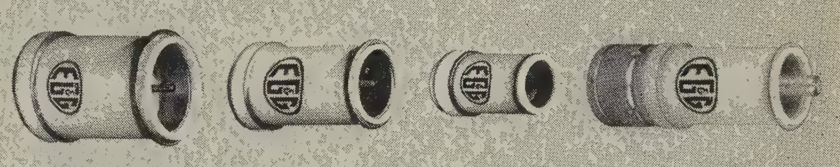


Model 7322/1802 functionally replaces 5949, 5948 and most 1257 glass tubes.

Model 7620/HY-1 functionally replaces 4C35, 5C22 and most 5949 glass tubes.

Model 7621/HY-2 functionally replaces 1258, 3C45 and most 4C35 glass tubes.

Model 7620/HY-1 plus A4-18 base electrically & mechanically replaces 5C22/HT-415 and 6587 glass tubes.



THYRATRONS EG&G's rugged, lightweight, durable thyratrons have all passed vigorous vibration and shock tests. They are designed to operate at high power levels, high repetition rates and high temperatures and can be mounted in any position.

	Model 7322/1802	Model 7620/HY-1	Model 7621/HY-2
● compact modular circuitry (length) (dia.)	5-3/4″ 3-3/8″	4-5/8″ 2-5/16″	2-1/2″ 1-1/5″
● light weight (lbs.)	2.07	0.82	0.13
● max. peak anode voltage	25,000	20,000	8,000
● max. peak anode current (amps)	1,500	500	90
● max. average current (amps)	1.5	0.5	0.1
● wide temperature capability	—55°C to +125°C ambient; 400°C envelope max.		
● long life	unique hydrogen reservoir in all models.		
● rugged dependability	all models pass vigorous shock and vibration tests.		
● cathode & reservoir warm-up time	10 min.	5 min.	30 sec.
● high plate dissipation factor	20 x 10^9	10 x 10^9	1 x 10^9

XCR-3 miniature VOLTAGE REGULATOR

Designed to operate at 2480 volts over current range of 20 to 300 microamperes, EG&G's corona-discharge voltage regulator tube is of rugged construction and has successfully passed stringent vibration and shock tests. Models can be built for regulation between 700v. and 4000v.

EDGERTON, GERMESHAUSEN & GRIER, INC.
174 Brookline Avenue, Boston 15, Massachusetts ● Las Vegas ● Santa Barbara

EG&G TECHNICAL REPRESENTATIVES—
J. D. Ryerson Assoc., Inc.—SYRACUSE, N. Y., P. O. Box 1400, 111 Kinne Road, GIbson 6-1771 • **G. Curtis Engel & Assoc., Inc.—RIDGEWOOD, N. J.,** 210 South Broad Street, GIlbert 4-1400; **PHILADELPHIA, Pa.,** P. O. Box 4383, Chestnut Hill 8-0892 • **S. S. Lee Assoc., Inc.—ORLANDO, Fla.,** 718 West Smith Avenue, CHerry 1-4445; **WINSTON-SALEM, N. C.,** P. O. Box 906, STate 8-0431; **HUNTSVILLE, Ala.,** Terry-Hutchens Bldg.—Rm. 210, JEfferson 6-0631; **WHEATON, Md.,** 2521 Ennalls Avenue, LOckwood 5-3066; **LUTHERVILLE, Md.,** P. O. Box 205, VAlley 3-3434 • **Dayton Assoc.—DAYTON, O.,** Talbot Tower—Suite1318, BAldwin 3-9621; **CLEVELAND, O.,** 3017 Snow Road, TUxedo 6-3525; **CINCINNATI, O.,** 4924 Zula Avenue, BAckburn 1-2349; **SOUTHGATE, Mich.,** 15332 Kennebec, AVenue 5-3125 • **Engineering Products Assoc.—ST. PAUL, Minn.,** 1821 University Avenue —Rm. 182, MIdway 6-3443 • **Gene French Co.—ALBUQUERQUE, N. M.,** 7900 Zuni Road, S.E., AMherst 8-2478; **SALT LAKE CITY, Utah,** 138 South Second East, EMpire 4-3057; **DENVER, Col.,** 1480 Hoyt, MAin 3-1458; **SCOTTSDALE, Ariz.,** 224 South Hinton Avenue, WHitney 6-3504 • **Kinrick Co.—ST. LOUIS, Mo.,** 222 Olympia Drive, JAckson 1-4877, MAin 1-1421 • **Stanley Enterprises—SEATTLE, Wash.,** 127 River Street, PArkway 3-3320 • **Mitchell Speairs Co.—FORT WORTH, Tex.,** 4944 James Avenue, WAbash 3-4657 • **J. T. Hill Co.—SAN GABRIEL, Calif.,** 420 South Pine Street, ATlantic 7-9633, CUmberland 3-6555; **SAN CARLOS, Calif.,** 1682 Laurel Street, LYtell 3-7693; **SAN DIEGO, Calif.,** 1864 Bacon Street, ACademy 3-7133

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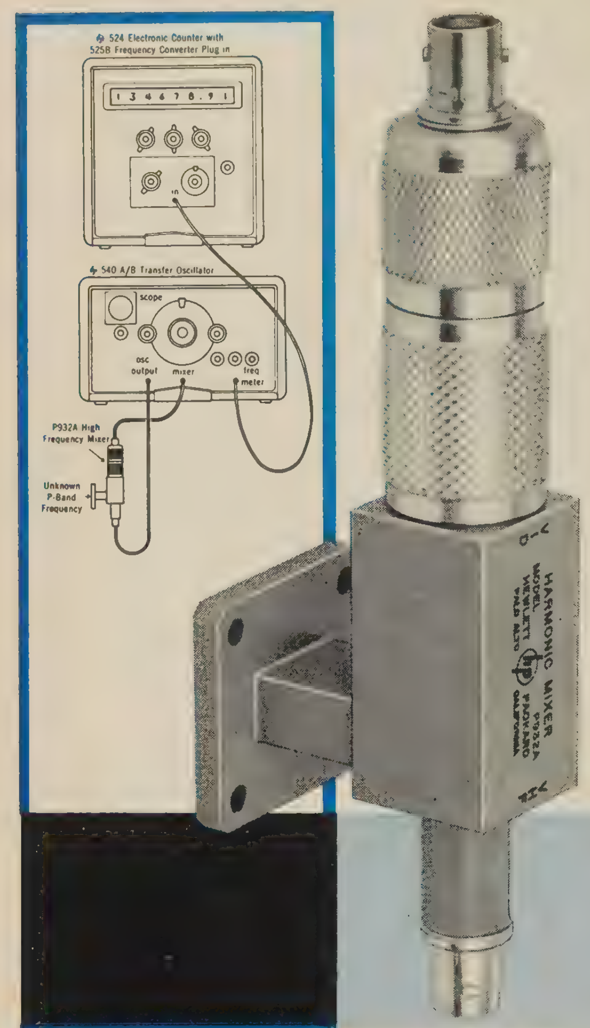
MEASURE FREQUENCIES TO 18 KM



with counter accuracy

New fixed tuned hp harmonic mixers offer "low frequency" measuring ease and accura have high sensitivity, obviate tuning delays

12.4 to 18 KMC P-Band *New hp P932A Harmonic Mi* mounts directly in your waveguide system and opera with an hp 540A or 540B Transfer Oscillator, as indica in the block diagram. The 540 Oscillator output is appl directly to the mixer, which generates harmonics and mi them with the unknown waveguide frequency. The mix beat frequency output is applied to the 540's oscillosc the oscillator tuned for zero beat scope indication, and oscillator frequency setting noted. Simple multiplicat of the 540 dial frequency by the harmonic number yields unknown to within 0.5%. Measuring the oscillator quency on an hp 524 series counter increases accuracy measurement on clean cw signals up to 1 part in 10^7.

hp P932A maximum input power is 100 mw, minimum vi output is 0.1 mv rms with 0 dbm input, output impeda 1000 ohms with 35 μμf shunt, sensitivity approximately – dbm. $250.00.

5 to 12.4 KMC New hp 934A Harmonic Mixer operates from 12.4 KMC, extends the range of the hp 540A Transfer Oscillator f 5 KMC to 12.4 KMC and offers the same advantages as the P93 including the fixed tuned feature eliminating tedious adjustm Maximum input power is 100 mw, typical sensitivity is —45 dbr mid-range points, minimum video output is 0.5 mv rms (0 dbm inp and output impedance is the same as hp P932A. Model 934A $15

220 MC to 5 KMC or 12.4 KMC Hewlett-Packard 540 Transfer O lators (see diagram) extend the range of the hp 524 series coun to 5 KMC (hp 540A) and 12.4 KMC (hp 540B), making possible quency measurements with counter accuracy well into the microw region. These oscillators also measure carrier frequency of pul determine carrier frequency and deviation of FM signals, and n sure frequency accurately despite high noise. hp 540A, $615.00. hp 54 $750.00. (Rack mount models $15.00 less.)

FREQUENCY MEASUREMENT

FREQUENCY RANGE	EQUIPMENT	TOTAL* PRICE
0 - 10 MC	524C or 524D Frequency Counter	$2,150.00
10 - 100 MC	524C/D + 525A Converter (0-10 MC) (10-100 MC)	$2,400.00
100 - 220 MC	524C/D + 525B Converter (0-10 MC) (100-220 MC)	$2,400.00
220 MC - 5 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A Transfer Oscillator (220 MC - 5 KMC)	$3,015.00
220 MC - 12.4 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A (220 MC-5 KMC) + 934A Harmonic Mixer (2-12.4 KMC)	$3,165.00
	-or-	
	524C/D + 525B (0-10 MC) (100-220 MC) 540B Transfer Oscillator (220 MC-12.4 KMC)	$3,150.00
12.4 - 18 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A (220 MC - 5 KMC) + P932A Harmonic Mixer (12.4 - 18 KMC)	$3,265.00**
	-or-	
	524C/D + 525B (0-10 MC) (100-220 MC) + 540B (220 MC-12.4 KMC) + P932A (12.4 - 18 KMC)	$3,400.00

*Based on 524D Frequency Counter $2,150.00. 524C price $2,300.00. Counter and Transfer Oscillator prices are for cabinet mounts; rack mounts are slightly lower.

**If coverage 5-12.4 KMC is desired, add 934A, $150.00.

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT-PACKARD COMPANY

1048C Page Mill Road
Cable "HEWPACK"

Palo Alto, California, U.S.A.
DAvenport 6-7000

Field representatives
in all principal areas.

HEWLETT-PACKARD S. A.
Cable "HEWPACKSA"

Rue du Vieux Billard No. 1
Tel. No. (022) 26. 43. 36

Geneva, Switzerland

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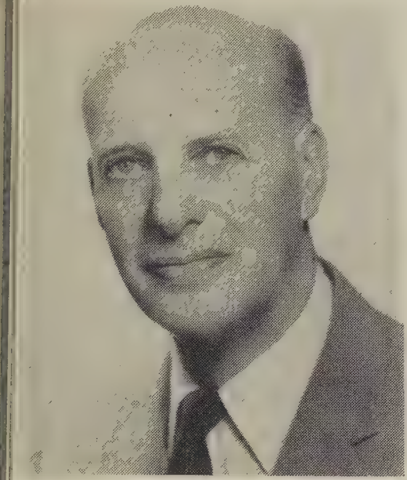
(Continued from page 30)

dulators and high voltage power sup- es necessary to the operation of micro- ve tubes.

—mwj—

AVENS ELECTED PRESIDENT OF NEW ELECTRONICS COMPANY

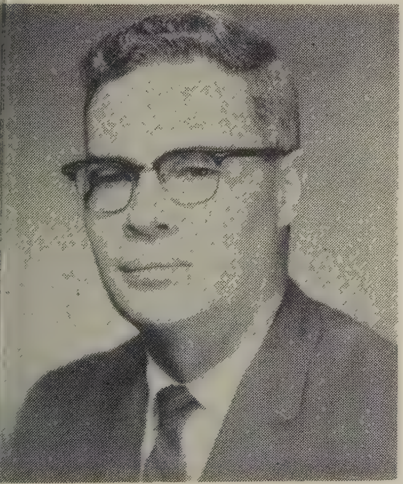


Benjamin B. Cravens has been elected sident of Microwave Corp. of America, mford, Conn., a new electronics com- y which will research, develop and nufacture waveguide components and ated electronic assemblies in Stamford, nn.

Mr. Cravens was formerly associated ith Raytheon Manufacturing Co. and her major electronics manufacturers.

—mwj—

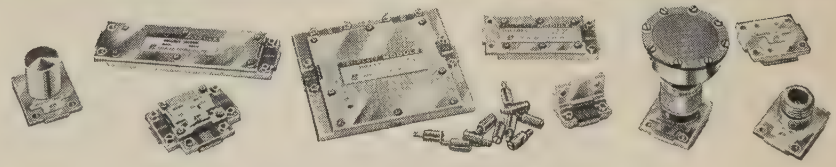
BOMAC BREAKS GROUND FOR NEW BUILDING



Bomac Laboratories, Beverly, Mass., an- ounces it has broken ground for a new uilding to house the Research Division nder the direction of Mr. Wellesley J. Dodds, Vice President, Engineering.

This new addition, the seventh to be dded to Bomac since 1951, will be lo- ated on Route 128, adjacent to the

(Continued on page 36)



HOW RAYTHEON PROVED A NEW THEORY IN 48 HOURS

. . . with Sanders TRI-PLATE® Modules

MONDAY — 10:00 AM: Jack Brule, a Microwave engineer in Raytheon's Equipment Division, tries out a new circuit idea on his teammates. Because of package size and weight limitations strip transmission line has to be the medium. All agree that it should be breadboarded first. They decide on TRI-PLATE modules as the best short-cut from schematic to working circuit. So, Jack reaches for his Sanders' Tri-Plate Module Catalog . . . and the telephone. Within minutes a Sanders application engineer is working on the problem.

MONDAY — 3:00 PM: The Sanders engineer arrives in Waltham, Mass. with a breadboarding kit of Tri-Plate Bends, Power Dividers, Terminations, Straight Sections, Crystal and Semiconductor Mounts, Directional Couplers, Co-Ax Transitions . . . all off the shelf.

TUESDAY — 2:00 PM: Another call from Raytheon to Sanders for additional Tri-Plate components.

TUESDAY — 3:30 PM: The components arrive at Raytheon by special messenger.

WEDNESDAY — 10:00 AM: The new Raytheon circuit checks out perfectly . . . and a new proprietory microwave package is born.

MORAL: Sanders has a complete line of Tri-Plate Modules always in stock . . . can deliver a circuit-mated breadboarding kit anywhere on short notice . . . will send you a Tri-Plate Module catalog on request.

®Trademark Sanders Associates, Inc.

SANDERS ASSOCIATES, INC.

Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

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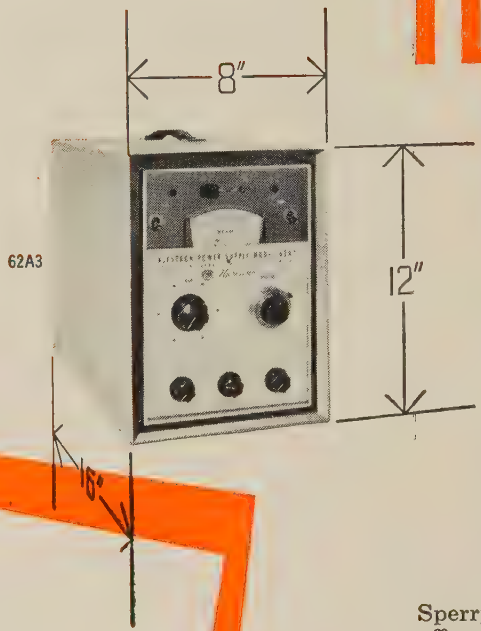
TIGHTLY PACKE



Smallest
and lightest
for its power
on the market

SPERRY
50 YEARS
1910 1960

Sperry Klystron Power Packages are offered in two sizes to meet any laboratory requirements.

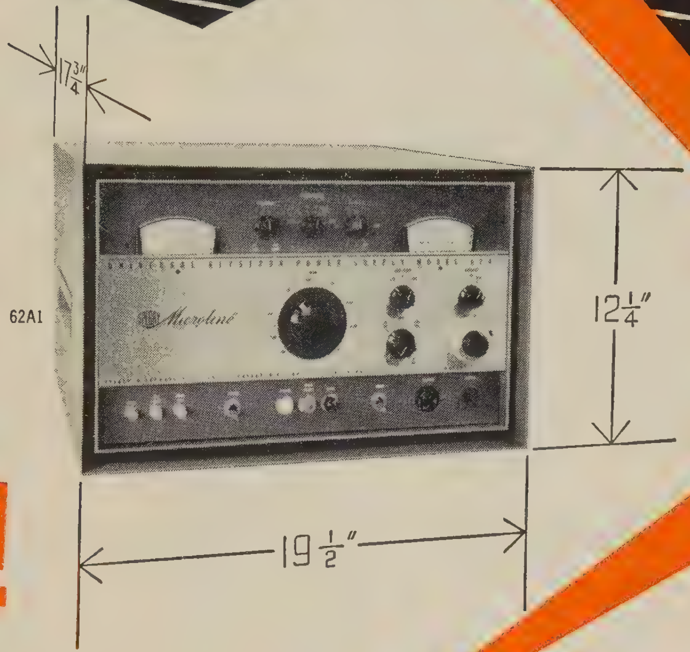
Model 62A1 Universal Klystron Power Supply delivers −200 to −4,000 volts from 0 to 150 ma. Extremely compact: 12¼″ high, 19¼″ wide, 17¾″ deep. Weighs only 125 lbs.

Model 62A3, is today's most versatile 700 volt Klystron Power Supply. It is the smallest and lightest package of its power on the market. Delivers up to 70 ma. Ideal for average laboratory use—and at a moderate price. Weighs only 32 lbs. and measures 8″ x 12″ x 16″.

Both units designed for ready adaptability to accessory connections. Excellent regulation, low ripple, stable operation.

Write for detailed information and applications of these packed-with-power units for general laboratory use.

POWER!



SPERRY *Microline*® KLYSTRON POWER SUPPLY

MODEL 62A3		MODEL 62A1
-200 to -700 volts Continuously adjustable 0-70 ma. ±1 volt line regulation 5 mv. max. ripple	BEAM	-200 to -4000 volts Continuously adjustable 0-150 ma. ± 1 volt line regulation 3 mv. max. ripple
0-1000 volts 0.1% regulation 5 mv. max. ripple	REFLECTOR	0 to -1000 volts .01% regulation 3 mv. max. ripple
6.3 volts @ 0-2 amp.	FILAMENT	6.3 volts @ 4 amp., with provision for external filament supply
2% accuracy	METERING	2% accuracy
0-150 v., peak to peak, all waveforms *Sawtooth:* 40-400 cps. *Square Wave:* 200-2000 cps. *Sine Wave:* line frequency *External Modulation:* direct or amplified	MODULATION	0-250 v., peak to peak, all waveforms *Sawtooth:* 40-400 cps. *Square Wave:* 200-2000 cps. *Sine Wave:* line frequency *External Modulation:* direct or amplified
8" x 12" x 16"	DIMENSIONS	12¼" x 19½" x 17¾"
32 lbs.	WEIGHT	125 lbs.
$550	PRICE	$1300

ERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORATION*

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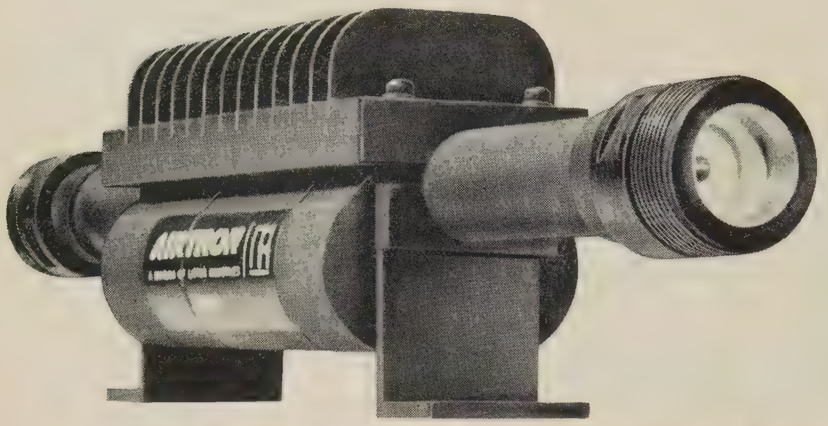
ONE
WAY



STREET

This particular Airtron ferrite isolator is a high-power broad-band coaxial unit. We make these and many other one-way streets for errant energy in a very broad variety of mechanical and electrical characteristics: many of them are from stock. Because we tailor and produce our own ferrite materials in our Advanced Devices Laboratory to meet special requirements, we can custom build for you with nominal lead time.

Here are condensed specifications for the isolator pictured:

Isolation	15db minimum.
Insertion loss	0.8db maximum over 20% bandwidth. (Can also be made to cover 50% bandwidth for ECM or CCM applications).
Power handling capacity	400 watts *average*. CW (Air cooled).
Input VSWR	1.12 maximum.
Frequency	S-Band or L-Band.
Material	Aluminum.
Line size	⅞-inch coax.
Connectors	L/T both ends, gender optional.
Length overall	13.85 inches nominal, S-Band. 16.84 inches nominal, L-Band.
Weight	3.50 lb. maximum, (S-Band unit).
Ambient Temperature	—20° to 100°C, (L-Band unit).

We invite your inquiry for additional information on Airtron's comprehensive line of ferrite isolators.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N. J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N. J.

Industry News

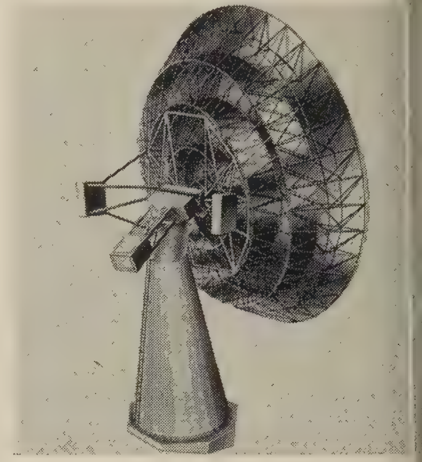
(*Continued from page 33*)

present facilities. It will be a 20, square foot, U-shaped, one story, b building, and is scheduled for complet late in the fall. With this addition, mac's facilities will total over 135, square feet.

Bomac became a subsidiary of Va Associates of Palo Alto, Cal. in Ma 1959. Besides Bomac, Varian's pres corporate structure includes Varian of C ada Ltd. in Georgetown, Ont.; S- Laboratories, Union, N.J.; Semicon sociates, Inc. in Lexington, Ky. and W sonville, Cal.; and Varian A. G. in Zur and Zug, Switzerland.

—*mwj*—

TELECOMPUTING CORP. AWARD CONTRACTS FOR ITS TETRAC ANTENNA



Orders totaling approximately $900,0 were awarded Telecomputing Corporatio Los Angeles, Cal., for tracking antenna including the first contracts for its ne Tetrac antenna, Wm. R. Whittaker, pr ident, announced.

Naval Research Laboratory has order an 85-foot Tetrac antenna for its rad telescope installation at Maryland Poi Observatory, Md. A 60-foot Tetrac being built for Naval Electronics Labor tory, Pt. Loma, Cal. Both units will used in tracking objects in space, and a scheduled for delivery for the later part the year.

Special design feature of Tetrac a tennas is its simplicity of fabrication ar assembly. Produced and shipped in mod lar components, it is designed to be a sembled and adjusted in the field. Tetr utilizes pre-tension truss, making accura adjustment possible.

Parabola dish face panels are made sandwich structures, utilizing forme aluminum skins which provide an exce lent weight-to-stiffness ratio. Combine with the pre-tension truss features, Tetra antennas offer close tolerance accuracy the reflective surface and give high a curacy results.

Tetrac is feasible for antennas from 3 to 300 foot diameters where high acc racy is necessary.

—*mwj*—

(*Continued on page 70*)

what's the veridicality *of a DeMornay-Bonardi standing wave detector?*

Verily, it's high. Since you want true readings from a slotted line, we've produced an instrument abounding in "truthfulness."

First we massacred the causes of mismatch. The D-B waveguide block, for example, is precision-formed in one piece to give it high internal uniformity. This pays off in an even path for the measured waves. Also, it minimizes residual VSWR. To wipe out warpage, we make the block of non-distorting, stress-free aluminum, precision-milled to assure absolute alignment with the probe carriage. Three leveling screws support the instrument without rocking.

Do we stop there? Not by your transverse travel! We use a 5-point kinematic carriage suspension which assures maximum linearity of probe motion. The carriage rides on stainless steel ball bearings, precision ground and spring loaded to keep perfect alignment. A large knob controls the carriage motion from a restful stationary position, leaving eyes free to watch the indicator. Knob speed is continuously variable from "vernier" to "fast," allowing you to speed up the quick measurements.

Your budget buys more. For a modest amount, you can equip any D-B instrument to handle another frequency band. Merely use a different size waveguide block and probe. Nine sizes of each are available—all interchangeable in 30 seconds, without loss of accuracy. Thus one instrument will measure from 12.4 KMC to 90 KMC and another from 5.8 KMC to 12.4 KMC.

Who needs tuning? D-B broad band probes with calibrated depth adjustment need no tuning over the allocated waveguide band, and yet are efficient at all frequencies. There's a special built-in miniature coaxial cable that flexes freely with the carriage motion, eliminating 95% of cable noise. Many more refinements in addition. Complete data sent on request.

DE MORNAY BONARDI *780 South Arroyo Parkway, Pasadena, California*

FROM THE MAKERS OF
STYROFLEX® COAXIAL CABLE...
PHELPS DODGE
RIGID RECTANGULAR SEAMLESS
WAVEGUIDES
...WITH MIRROR-SMOOTH FINISH!

Phelps Dodge waveguides are carefully extruded and cold drawn in rectangular seamless shapes from oxygen free copper and commercial bronze, 90% for highest quality and finest performance at high frequencies.

Control of the inner surfaces of every guide is closely maintained by Phelps Dodge throughout fabrication to assure the most critical type of mirror-smooth finish—an essential for ultimate signal strength. All Phelps Dodge waveguides are made in accordance with applicable military and commercial specifications and are available in the following family of sizes:

RG-104/U · RG-112/U · RG-48/U · RG-49/U · RG-50/U · RG-51/U
RG-52/U · RG-91/U · RG-53/U · RG-110/U · RG-109/U
WR-229 · WR-159 · WR-75 · WR-51 · WR-34

Guides are fabricated in 12-foot mill lengths and in longer lengths on special order. Contact your Phelps Dodge representative for full information.

PHELPS DODGE COPPER PRODUCTS
CORPORATION
300 Park Avenue, New York 22, N.Y.

PHELPS DODGE COPPER PRODUCTS CORPORATION
P D

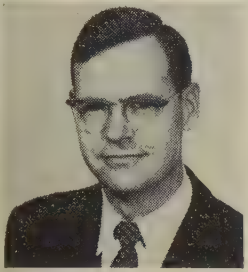
Circle Reader Service Card 30

CONTRIBUTORS IN THIS ISSUE

ES T. ELFVING was born in Stockholm, Sweden, on December 18, 1930. He entered United States in 1950 and received his BS degree in electrical engineering in January . While in school and directly following graduation he worked with Isoflex Corp., Bur- me, Cal., where he developed test procedures and designed and built test equipment for uation of thermal properties of insulation materials.

From 1954 to 1956 he served on active duty with the U.S. Army Signal Corps where he d and repaired field radio and aircraft communication equipment.

In August 1956 he joined the antenna section of Sylvania Electronic Defense Laboratories, ntain View, Cal., where he has been engaged in design of antennas for electronic counter- ures systems. Mr. Elfving is a member of the IRE and the Professional Groups on An- as and Propagation and Microwave Theory and Techniques.



RAYMOND E. FRANKS was born in Gainesville, Texas, on August 26, 1928. He received a BS degree in electrical engineering in 1950 from Rice Institute.

From 1950 to 1957, he was with the General Electric Co. Missiles and Ordnance Systems Division in Pittsfield, Mass., engaged in the design and evaluation of fire control and search radar systems. Mr. Franks joined the Sylvania Electronic Defense Laboratories, Mountain View, Cal. in May 1957, and since that time has been engaged in the development of broadband antenna systems for electronic countermeasures. He is a member of Tau Beta Pi.

J. R. HECHTEL was born on May 21, 1913 at Schwabach, Germany and graduated the Institute of Technology at Munich in 1938 with the degree of Diploma Physicist, and the degree of Doctor of Natural Science in 1940.

From 1940 to 1945, he worked as a research physicist at the Deutsche Versuchsanstalt fur ahrt. He was head of the Electron Tube Laboratory his last two years there. From 1949 1951, he was employed as a research physicist with the C. Lorenz A. G., Stuttgart. He the same position with Telefunken until 1958. He was head of the Microwave Tube t. from 1956-58.

Since November, 1958, he has been employed as a physicist in the research department of Michelson Laboratory, China Lake, Cal. He is presently head of the Electricity and Mag- sm Branch. Dr. Hechtel has had 19 technical papers published.

BERNARD J. LAMBERTY was born in 1928, and received his BS degree in electrical engineering from Illinois Institute of Technology in 1950. The following year he was a graduate student at Ohio State University and a research associate in the Antenna Laboratory. He was with the Microwave Group at Gilfillan Brothers in Los Angeles, Cal. from 1951 to 1955.

Mr. Lamberty then became a member of the faculty of the Electronic Engineering Department at California State Polytechnic College. He was later inducted into the Army and assigned to the Telemetry Research Section of the Range Instrumentation Division at White Sands Proving Ground, New Mexico. During this time he was a part-time instructor in the Electrical Engineering Department at New Mexico State University.

After his discharge, Mr. Lamberty returned to the faculty staff of California State Polytechnic College. Since 1957, he has been with the Sylvania Electronic Defense Laboratories where he is head of the Applied Electrodynamics group.

VARD B. McMILLAN is a research director and inventor. In charge of the instrument re- ch group within the Physical Research Laboratory of the Dow Chemical Co. during the od 1940-1942, among his original contributions were those in the fields of electronic ng, electrically conductive plastics, and geophysics.

In 1942 he went to the Radiation Laboratory at M. I. T. and finally became head of an nna section, where together with R.M. Redheffer he developed and introduced many of original concepts of the radome field. After the war he founded McMillan Laboratory, which has concerned itself with various industrial and defense instrumentation and ronic problems.

He and his laboratory are well known for original work and patents in the fields of mes, high frequency absorbers in confined spaces, radar installation in commercial air- ts, radio frequency interference isolation and power line filtering devices and cables. He senior member of the I.R.E., the A.P.S. and the A.C.S.

HANS J. SCHMITT received the degree of Dipl. Phys. from the University of Goettingen, Germany in 1954, his Dr. rer. nat. degree in 1955 from the same University.

From 1955 to 1956 he carried out research work in dielectrics and microwave absorbers as research assistant in Goettingen. He became associated with Harvard University as research fellow in 1957, working on scattering problems and antenna theory. Since 1958 he has been teaching as assistant professor in the Department of Applied Physics and Engineering. He also serves as a consultant to McMillan Laboratory, Inc. in Ipswich, Mass. He is a member of Sigma Xi.

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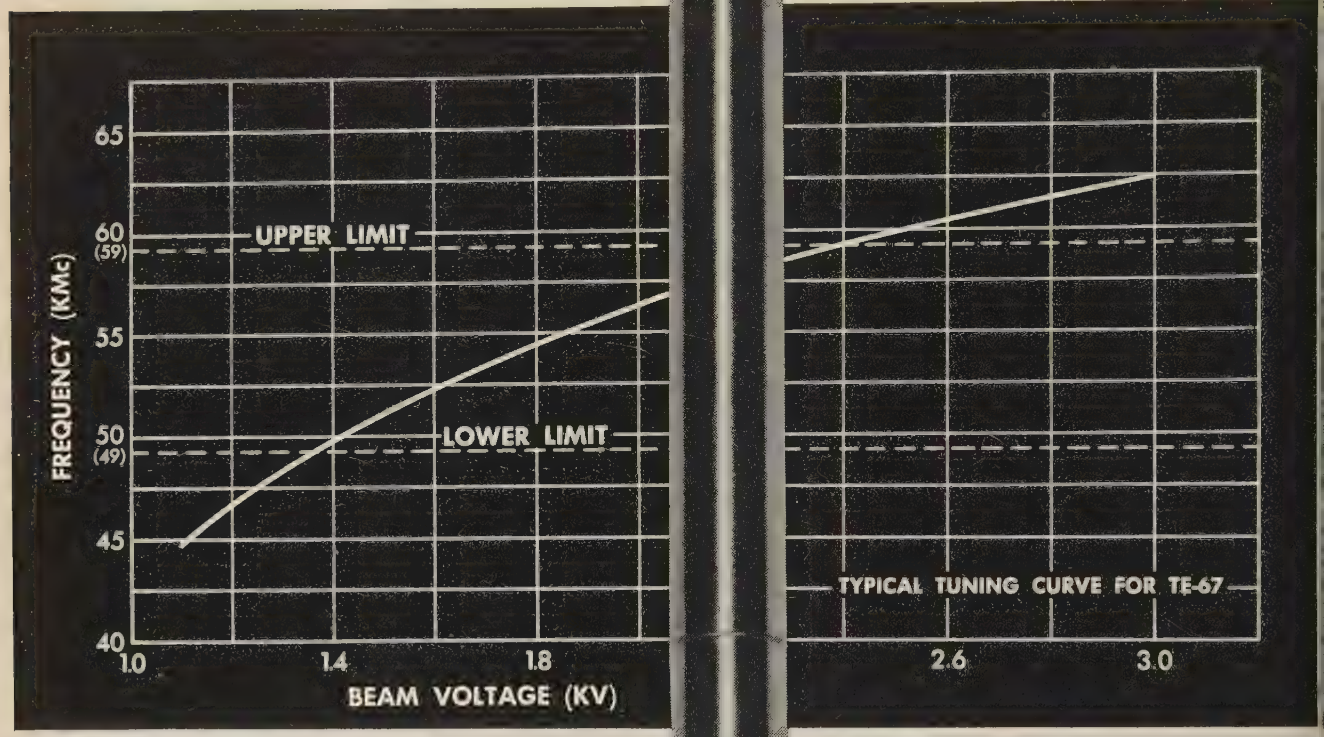

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Frequency Range	49kmc—59kmc
Anode Voltage	1000—3000 volts
Power Output	5mw average
Beam Current	5ma
Magnetic Field	1300 gauss (minimum)
Heater Voltage	6.3±10%

MECHANICAL DATA

Output Flange	Special adapter to RG-98/U
Maximum Diameter	0.625″
Length	8″
Mounting Position	Any
Weight	5 oz.*

*Without magnet (tube only). Magnets are available.

Also available: Type TE-66 with frequency range of 61 kmc to 71 kmc.
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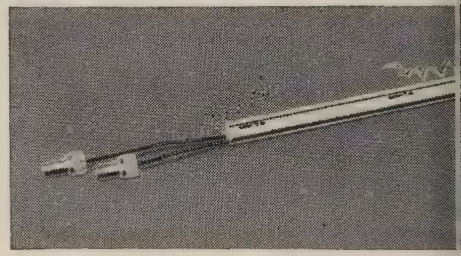

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FIRST OF TWO PARTS

NTRODUCTION

Most microwave tubes use electron beams which are g compared to their width. As the perveance of such ms is relatively high (of the order of 10^{-6} amps/ ts$^{3/2}$), space charge effects play an important role. s means that an electron beam without the presence of ernal focusing fields would rapidly increase its initial th.

he oldest and most frequently used method of sup- ssing excessive beam spreading is a homogeneous mag- ic field parallel to the desired motion of electrons. is field may be produced by an electromagnet (sole- id) or by a permanent magnet. Both methods have ir disadvantages. The electromagnet consumes energy d needs a power supply which has a volume and a ight exceeding that of the tube itself. The permanent gnet, besides its large volume and weight, has an ex- nal stray field. For some materials the field also de- nds on the temperature.

In some traveling wave tubes and backward wave cillators, the homogeneous magnetic field has been re- aced by spatial periodic magnetic fields. In this case nsiderable weight and space are saved. However, the oblem of temperature compensation still remains.

The above-mentioned disadvantages may not be too rious in a ground based system, but they are of pre- minant importance if a microwave tube is to be used an airborne or satellite borne system.

Electrostatic focusing in microwave tubes which would free of all these drawbacks is very attractive. The idea as old as the principle of velocity-modulated tubes it- f. Hahn and Metcalf [1], in their first paper on velo- y-modulated tubes, proposed electrostatic lenses. Since n a great number of different focusing schemes have en proposed and experimentally tested. However, the gh perveance which is used in microwave tubes makes ctrostatic focusing of a relatively long electron beam an tremely difficult task and in only the last few years some ogress has been achieved.

The problem of focusing an electron beam in a micro- ve tube is considerably different from electron-optical oblems encountered in other electron-optical devices, for ample in an electron microscope or cathode-ray tube. Rather than forming an image of an object, the aim is maintaining an approximately constant beam diameter and, as far as possible, laminar flow over a certain length of the beam. This means that the outward directed space charge force has to be compensated, either in each moment or on the average by an opposite focusing force. In a theoretical treatment, space charge forces, which are normally neglected in electron optics, play an important role.

Another point to be considered in microwave tubes is the ratio of beam diameter to the inner diameter of the surrounding electrodes. In most electron devices this ratio is kept low in order to minimize spherical abberation. However, in microwave tubes the situation is entirely different. As the surrounding electrodes primarily have the function of generating r.f. fields, the beam has to pass as close as possible to these electrodes in order to get good coupling between beam and fields. If the same electrodes are part of an electrostatic focusing system, this system will have strong spherical abberation. Including this effect renders a theoretical treatment of the problem much more difficult. The commonly used paraxial ray equation, for example, cannot be used to describe the path of an electron at the edge of the beam with sufficient accuracy.

An important feature of a focusing system for microwave tubes is its stability with respect to the initial conditions for the beam. A certain deviation from the correct value of current, diameter, and initial slope of the beam should not lead to intolerable changes in beam diameter.

Before discussing the different systems which have been proposed or tried, a few basic electron-optical arrangements providing a focusing action shall be considered. These are the "Einzel-lens" (single-lens) and the electric fields between coaxial cylinders and parallel planes. All the other more complicated systems can be reduced to these basic arrangements.

The Einzel-Lens (single-lens or univoltage lens)

The Einzel-lens in its simplest form consists of three diaphragms aligned along a common axis (Figure 1). The two outer electrodes have the same potential. The potential of the middle electrode may be higher or lower. In

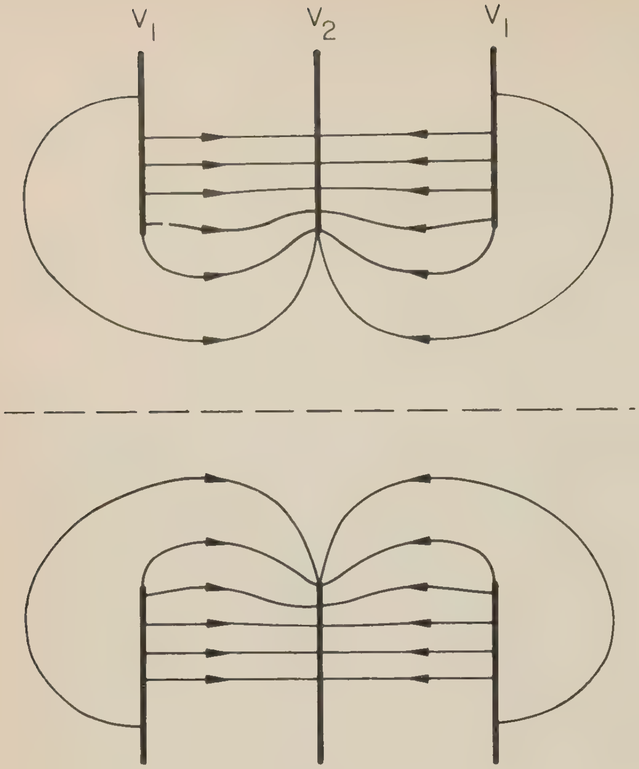


Figure 1 — Electric field of an "Einzel-lens."

the case of axial symmetry the apertures in the diaphragm are circular. The same arrangement can be used for focusing ribbon or sheet beams, if each diaphragm is replaced by two semi-infinite planes separated by the plane of symmetry. Now let us consider the electric field of an Einzel-lens, shown in Figure 1, where the voltage of the outer electrodes is higher than that of the inner electrode. In Figure 2 the trajectory of electrons in the Einzel-lens is shown. An electron approaching the lens at first comes into a region where the force acting upon it is directed away from the axis. Between the first and the second aperture the direction of the field changes and the force on the electron is directed inward. Finally, between the second and the third aperture the direction of force changes again from inward to outward. Also shown in Figure 2 is the light-optical analogue of this lens.

If the voltage of the middle electrode is higher than that of the outer ones, we first have an inward force, then an outward one and finally again an inward force acting upon the electron. In both cases the focusing action corresponding to the inward force is stronger than the defocusing action, that is, the lens is always convergent.

There are two reasons for this convergence. The first is that the potential in the region where focusing action takes place is lower than that of the defocusing region. Therefore the electrons travel slower in that region and the inward directed force acts a longer time. The second reason lies in the fact that the electric fields are stronger at a greater distance from the axis. An electron which first passed a defocusing zone and increased its distance from the axis, comes into a region of stronger focusing action according to the greater distance from the axis, and vice versa.

Now it can be seen how the Einzel-lens may be used to focus a high perveance beam. In the presence of space charge we have an additional outward directed forc which is proportional to the beam current. The ligh optical analogue of the space charge would be a succe sion of divergent lenses (Figure 3).

For a certain beam current the focusing action of a giv system will be equal to the defocusing action of the spa charge. An electron beam entering the system parallel the axis therefore will also leave it parallel. This is t condition required for beam focusing in a microwave tub

Deflection Focusing Between Coaxial Cylinders

The focusing properties of the electric field betwe coaxial cylinders have been known since the early days electron optics. Let us consider the arrangement of Figu 4 which shows a cross-section through two coaxial cyli ders in a plane perpendicular to the axis. For an electr traveling on a circular path with radius r_0 and velocity the outward directed centrifugal force must be equal the inward directed force from the electric field.

Another electron starting at the same point with t same velocity v_0, but with an additional small radial, ou ward directed velocity component, comes into a region lower potential, where its velocity and therefore the ce trifugal force is smaller. Because of the reduced centrif gal force, the electron will come back to its original di tance r_0 from the center. On the other hand, an electr having a small inward directed velocity component com into a region of higher potential where its velocity ar the centrifugal force are higher. This electron will al return to its initial distance r_0. Analysis shows that i the absence of space charge effects the electrons startin from a common point are collected in a point at th

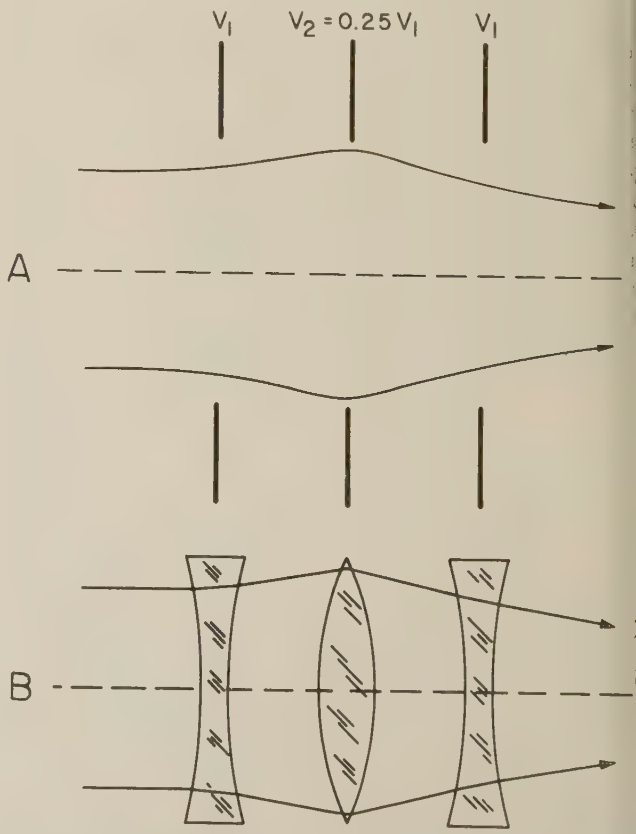
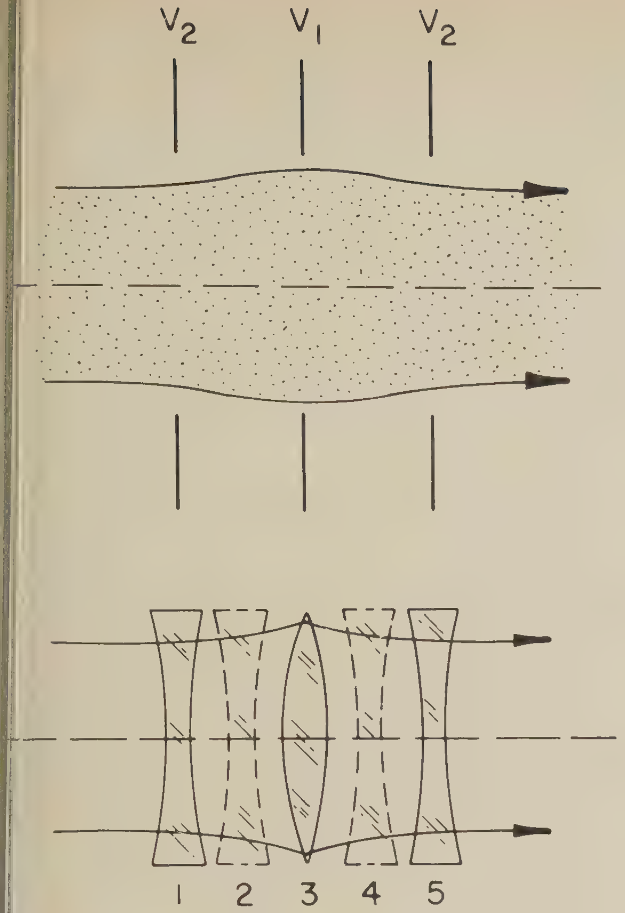


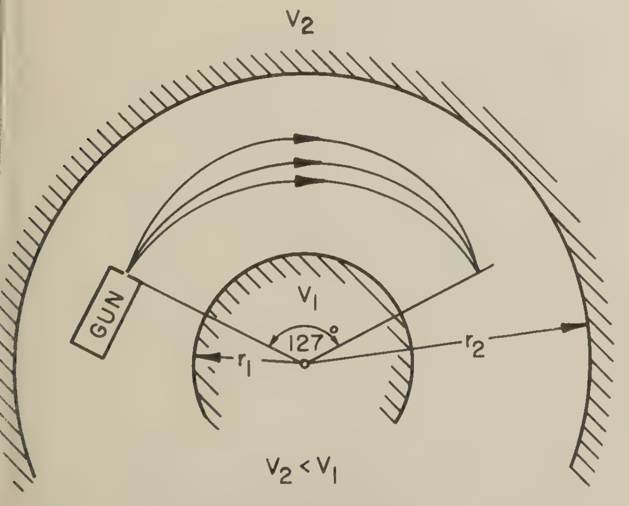
Figure 2 — A) Electron trajectories in an "Einzel-lens" neg lecting space charge effects.
B) Light-optical analog of an "Einzel-lens."



ure 3 — Electron trajectories in an "Einzel-lens" including space-charge effects and light-optical analog. Lenses 2 and 4 represent space charge.

me distance r from the center with an angular disacement of 127°. If the electron source has a certain tension in the direction of the axis, a line focus is rmed as an image of the electron source.

Now the properties of the same system in the presence space charge shall be discussed. A certain current flows circular direction within a region bounded by two aginary cylinders of radii $r_0 - \Delta r$ and $r_0 + \Delta r$, as own in Figure 5. It is of interest to determine the contions for this type of electronic motion to be stable.



gure 4 — Electron trajectories between coaxial cylinders neglecting space charge effects.

The electric field in the presence of space charge can be calculated by integrating Poisson's equation. In Figure 5 the vector E_0 symbolizes the field which would exist without space charge. E_ρ is the field component originating from the space charge. Similar to the case without space charge we have again the condition that the centrifugal force has to be equal to the electric force for each radius within $r = r_0 \pm \Delta r$. Assuming $\Delta r << r$ this condition can be fulfilled by a current

$$I = 8\epsilon_0 \left(\frac{2e}{m}\right)^{1/2} \frac{\Delta r w}{r_0^2} V_0^{3/2} \text{ (amps)} \qquad (1)$$

where w is the width of the beam measured in axial direction, e and m are the charge and the mass of an electron, ϵ_0 the dielectric constant of vacuum and V_0 the potential at $r = r_0$, which is related to the velocity v_0 by the equation

$$\frac{mv_0^2}{2} = eV_0.$$

Surprisingly, the expression for I does not contain the radii and voltages of the two cylinders producing the focusing field, but only the radius of curvature of the electron stream and its thickness. Of course the fact that the electrons move in a circle with radius r_0, implicitly includes certain conditions about the field generating this type of motion.

Dividing Equation 1 by $V_0^{3/2}$ we obtain the perveance

$$\frac{I}{V_0^{3/2}} = P = \left(\frac{2e}{m}\right)^{1/2} 8\epsilon_0 \frac{\Delta r w}{r_0^2}$$

$$= 42 \times 10^{-6} \frac{\Delta r w}{r_0^2} \left(\frac{\text{amps}}{\text{volts}^{3/2}}\right) \qquad (2)$$

Taking as an example $\Delta r = 0.1$ cm

$r_0 = 1$ cm

$w = 1$ cm

the perveance of the system is

$$P = 4.2 \times 10^{-6} \left(\frac{\text{amps}}{\text{volts}^{3/2}}\right).$$

This relatively high value perveance indicates the effectiveness of this type of focusing for microwave tubes.

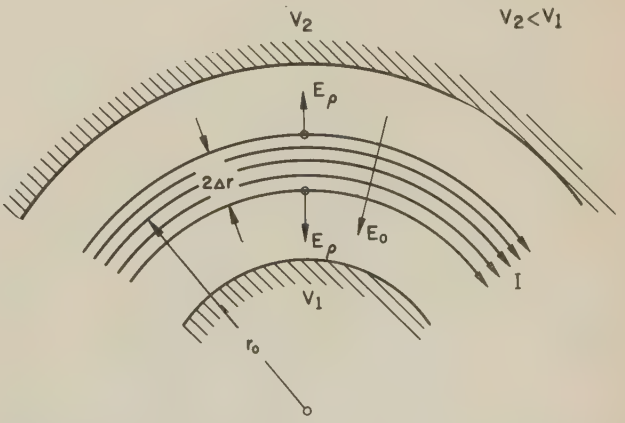


Figure 5 — Electron trajectories between coaxial cylinders including space charge effects.

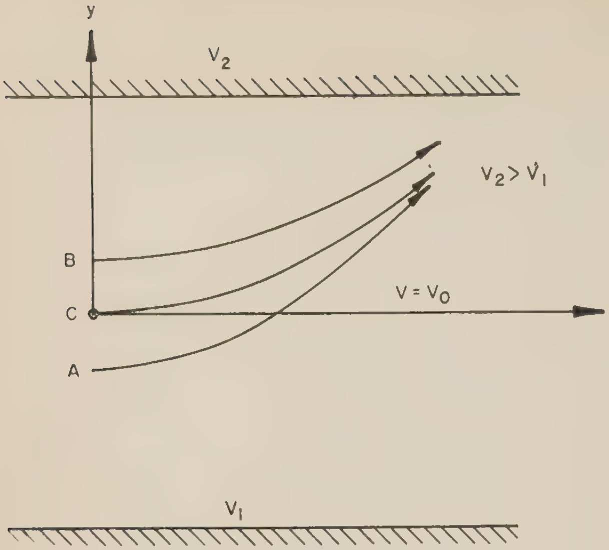


Figure 6 — Electron trajectories between parallel planes without space charge.

The circular motion of electrons can be combined with a longitudinal one in the direction of the axis. This is done for example in Harris' focusing system, in Watkin's Helitron and in the Russian spiratron. The focusing properties in radial direction are of course unchanged by such an additional motion in axial direction.

Deflection Focusing Between Parallel Plates

Let us consider an electron entering the field between parallel plates at a certain point A, with velocity $v_x = v_0$ perpendicular to the field as shown in Figure 6. As the field in y — direction is constant and in x — direction zero, the electron describes a parabola. A second electron entering the field in the same direction but at a point B closer to the electrode with the higher voltage will also describe a parabola. However, if both electrons are emitted by a unipotential cathode, the second electron will have a higher velocity v_x according to the higher potential in point B. Therefore the curvature for the second parabola is smaller than that of the first one.

For the same reason an electron entering the deflection field at point C, being closer to the electrode with the lower voltage, will describe a parabola having larger curvature. The difference in the curvature of trajectories for different starting points results in a focusing action, though there is not a single crossover as can be seen from Figure 6. Again, of more importance are the properties of this system under the influence of space charge. Let us assume a ribbon beam of a certain thickness entering the deflection system parallel to the x axis. As we have seen, the focusing properties of the electric field without space charge tend to decrease the beam thickness. On the other hand, space charge forces tend to increase the thickness of the beam. For the total field we can establish the condition that the thickness of the beam remains constant or, in other words, that the edge electrons follow the same trajectory as the electrons in the middle of the beam, except for a certain displacement parallel to the x axis. The current which satisfies this condition is

$$I = \epsilon_0 \left(\frac{2e}{m}\right)^{1/2} \frac{E_0^2 tw}{V_0^{1/2}} \text{(amps)} \qquad (3)$$

where t is the thickness of the beam, w its width (measured in z-direction, perpendicular to x and y), E_0 t electric field without space charge, and V_0 the potent corresponding to the entrance velocity v_0. At $x = 0$ t radius of curvature of the parabola described by the el trons is

$$R = \frac{2V_0}{E_0} \qquad ($$

Combining Equations 3 and 4 we finally get

$$I = 4\epsilon_0 \left(\frac{2e}{m}\right)^{1/2} \frac{tw}{R^2} V_0^{3/2}$$

and
$$P = \frac{I}{V_0^{3/2}} = 4\epsilon_0 \left(\frac{2e}{m}\right)^{1/2} \frac{tw}{R^2}$$

$$= 21 \times 10^{-6} \frac{tw}{R^2}\left(\frac{\text{amps}}{\text{volts}^{3/2}}\right) \qquad ($$

Again we have obtained a rather surprising result. T perveance of a sheet beam which can be focused in deflection field between parallel plates depends only the thickness of the beam and on the radius of curvatu of the trajectories the electrons describe in this field.

Comparing Equation 5 to Equation 2, which is valid f the focusing of a sheet beam between coaxial cylinde we see that the two equations become identical if t substituted by $2\triangle r$ and R by r_0. This means that t electric fields between coaxial cylinders and between par lel plates are equivalent with respect to the capability focusing high perveance sheet beams.

The idea that any electric field which causes an electr to move on a curved trajectory has focusing properti and can be used to confine a ribbon beam under spa charge conditions was apparently first conceived by W. Waters [2].

2. UNIFORM FIELDS

Pure Space Charge Fields (Space Charge Focusing)

The simplest of all existing focusing schemes is o in which no other fields are employed except the spa

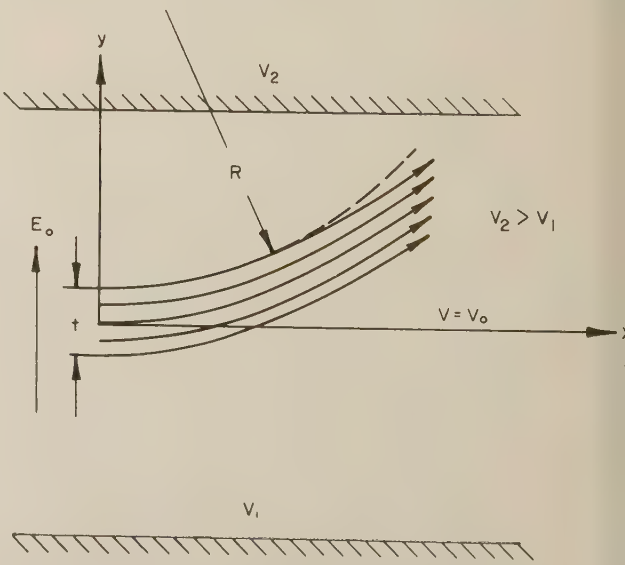
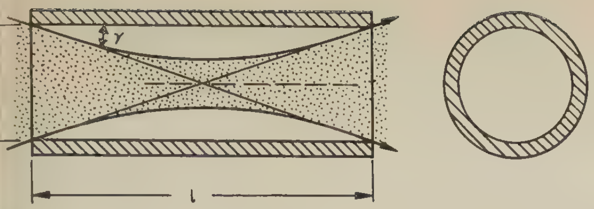


Figure 7 — Electron trajectories between parallel planes i cluding space charge effects.



ure 8 — Space charge focusing of a cylindrical beam under optimum conditions.

rge field of the electron beam. Sometimes this method called "space charge focusing." This designation is newhat misleading, as there is no real focusing action.

The current that can be transmitted by an electron m through a tube of a given cross-section and length a maximum if the beam enters the tube with a certain ial convergence. Consider a circular tube of diameter nd length l as shown in Figure 8. The initial slope of edge electrons must be

$$\tan\gamma = -\frac{d}{l}$$

is means that the initial direction of electrons coin- es with the diagonal in a rectangle of width d and gth l. The electrons leave the tube at the same angle y enter. The minimum beam diameter is given by

$$d_{min} = 0.43\ d$$

perveance of such a beam is

$$P = 39 \times 10^{-6} \left(\frac{d}{l}\right)^2 \left(\frac{\text{amps}}{\text{volts}^{3/2}}\right) \qquad (6)$$

d is not too small compared to l, relatively high values perveance can be reached. In a gridless klystron, the ft tube diameter d is limited by the beam coupling efficient which rapidly decays near the axis if d becomes large. Measured in normalized units, the upper limit

$kd = \frac{\omega d}{v_e}$ is about 2. The length l in a klystron is en by the distance between two adjacent gaps. In oscillator a normalized value of $k \cdot l$ close to $3.3\pi =$ 4 is most frequently used. This can also be regarded a typical value in a two-cavity amplifier. Assuming

$\frac{d}{l} = \frac{2}{10}$, we obtain an approximate value of perveance

$\approx 1.5 \times 10^{-6}$ amps/volts$^{3/2}$. This value does not take o account the lens effects of the r.f. field, which re- ce the maximum usable value of perveance to some gree.

If we have a sheet beam the situation is somewhat dif- ent. To transmit the maximum possible current through drift tube of rectangular cross-section we again have condition that the beam is convergent when entering tube. However, the minimum beam thickness is zero, least theoretically, if thermal velocities of the electrons neglected (cf. Figure 9).

If the initial thickness of the beam is b, its width a, and e length of the drift tube l, the maximum usable per- ance of the beam is approximately

$$I_o/V_o^{3/2} = \frac{ab}{l^2} \times 84 \times 10^{-6} \text{ amps/volts}^{3/2}.$$

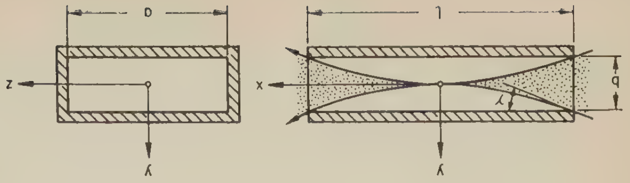


Figure 9 — Space charge focusing of a ribbon beam.

The initial slope is given by

$$\tan\gamma = -\frac{2b}{l}.$$

To calculate the maximum possible perveance, the normalized initial thickness of the beam is assumed to be $kb = 2$ and the normalized length $kl = 10$, similar to the case of the circular beam. In order to maintain an approximately constant r.f. field across the width of the beam, a is not allowed to exceed a certain fraction of the free space wave-length λ_o, for example $\lambda_o/5$. With $a = \lambda_o/5$ the normalized width ka of the beam is

$$ka = 2\pi \times \frac{1}{5} \times \frac{c}{v_e} (c = \text{velocity of light},$$

$$v_e = \text{velocity of electrons}).$$

ka and consequently the perveance in this case depend on the beam voltage. For a voltage of 10 kvolts c/v_e is approximately equal to 5 and $ka = 2\pi$. With this value we obtain a perveance of $P = 10.6 \times 10^{-6}$ amps/volts$^{3/2}$, which is much higher than the maximum perveance possible with a circular beam.

The method of space charge focusing has been used in klystron amplifiers and oscillators having beams of circular cross-section. At a frequency of 3000 Mc a c.w. power of the order of one kw has been achieved. At 10,000 Mc the c.w. power is several hundred watts. Amplifiers have been developed for frequencies up to 11,000 Mc and power levels of approximately 20 w c.w.

Grids are sometimes employed in tubes for pulsed operation at higher power levels [3]. These grids allow the use of larger beam diameters without deterioration of the beam coupling coefficient. With a larger beam diameter the beam can also be longer. In this way it is possible to construct a three-cavity amplifier. Figure 10 shows a schematic diagram of such a tube developed by the Sperry Rand Corporation. The peak power output of one of these tubes is 37 kw, its gain 30 db, and the frequency 960 to 1215 Mc. A similar tube for the frequency range from 2700 to 2900 Mc has a peak power output of 15 kw.

The main disadvantage of this principle lies in the fact

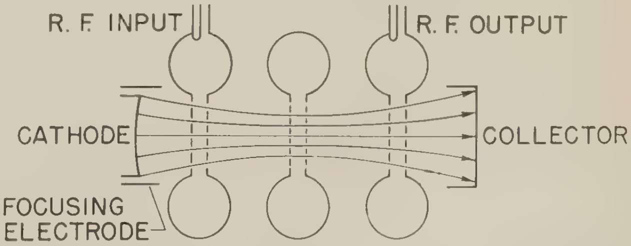


Figure 10 — Simplified diagram of a klystron amplifier using space charge focusing.

that a certain fraction of the beam current is intercepted by the grids. This not only reduces the efficiency of the tube but causes an elevated temperature of the grids, which limits the average power of such a tube to rather low values.

Focusing by Coaxial Cylinders

The focusing properties of the electric field between coaxial cylinders have been employed in various low and medium power oscillators and amplifiers. There are two ways in which this method has been used:

a) The electrons move in planes perpendicular to the axis of the focusing cylinders. The trajectories are approximately circles. The magnetless "magnetron," developed by Versnel and Jonker [4, 5], represents this type of electronic motion.

b) The electrons move in helical paths. This means that a constant velocity component in the direction of the axis is superimposed on the motion described in (a). Examples of this kind are the so-called "Harris flow" [6], Tchernov's "spiratron" [7, 8], and the "helitron" [9] of Watkins and Wada.

Figure 11 shows a schematic diagram of the magnetless "magnetron." The inner focusing cylinder is divided by slits into eight strips. These strips form together with a short circuited transmission line, which is not shown in the drawing, a resonant circuit. The electron gun produces a ribbon-shaped electron beam. With properly adjusted voltages and in the absence of r.f. fields, the electrons travel in circles. If the transit time of an electron between two adjacent slits is approximately equal to half a period of the resonant circuit, oscillations are possible. Electrons that have gained or lost energy in the r.f. field approach the outer or the inner cylinder, as shown in Figure 11.

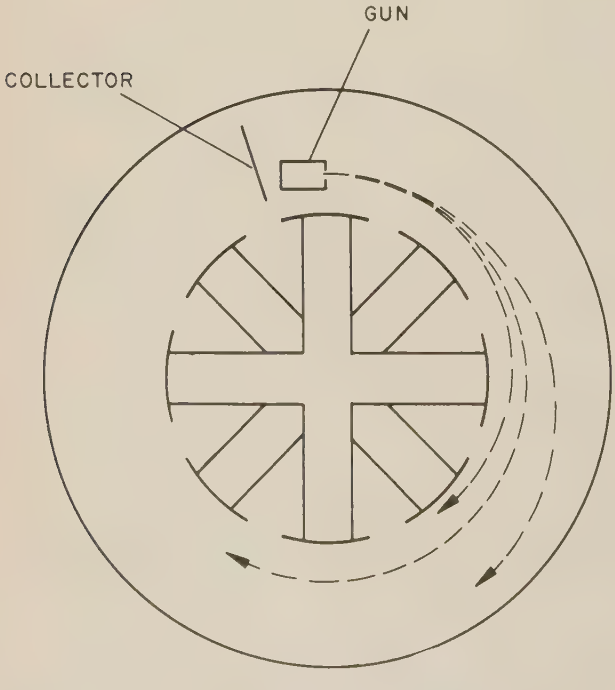


Figure 11 — Magnetless magnetron according to Versnel and Jonker.

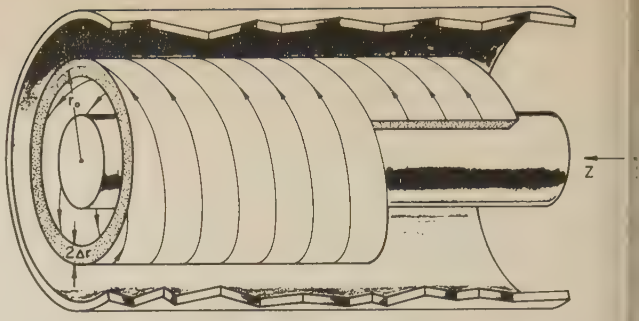


Figure 12 — Helical electron flow between coaxial cylinders used in the helitron, spiratron and Harris-flow.

The electrical data of this tube are the following:

Frequency	$f = 230$ to 420 mc
Beam voltage	$V_o = 100$ to 260 volts
Beam current	$I_o = 1.4$ to 5.9 ma
Perveance	$I_o/V_o^{3/2} = 1.4 \times 10^{-6}$ amps/volts^3
Beam Transmission	50 to 60%
r.f. power	some tens of mwatts

The perveance of the system comes very close to th theoretical value calculated from Equation 2, using th dimensions given by Versnel and Jonker. This tube only of theoretical interest since it is restricted to sma power levels and cannot be tuned electronically.

Consider the second case where the electrons move helical paths as shown in Figure 12. In addition to th angular velocity $v_\theta = r\theta$ we now have a longitudin velocity component v_z. The voltages corresponding these velocities are

$$V_\theta = \frac{m}{2e} v_\theta^2$$

and

$$V_z = \frac{m}{2e} v_z^2 .$$

Assuming again that Δr is small compared to r_o, th maximum current which can be focused in such a syste is given by

$$I = 16\pi\epsilon_o \sqrt{\frac{2e}{m}} \frac{\Delta r}{r_o} \sqrt{V_z V_\theta}$$

$$= 265 \times 10^{-6} \frac{\Delta r}{r_o} \sqrt{V_z V_\theta} \qquad (7$$

Introducing the angle α, which represents the pitch the helical electron paths, V_z can be expressed by V_θ ar vice versa. Using the relation

$$\tan\alpha = \frac{v_z}{v_\theta} ,$$

Equation 7 can be written in the two following forms:

$$I = 265 \times 10^{-6} \frac{\Delta r}{r_o} \tan\alpha \, V_\theta^{3/2} \qquad (8$$

$$I = 265 \times 10^{-6} \frac{\Delta r}{r_o} \operatorname{ctn}^2\alpha \, V_z^{3/2}, \qquad (9$$

TABLE I

Max. perveance and efficiency of a focusing system as shown in Figure 12 with $\triangle r/r_o = 0.1$

Efficiency = $\frac{\text{Useful power}}{\text{Total power}}$ x 100	r.f. field in the θ-direction		r.f. field in the z-direction	
	α °	$\frac{I}{V_\theta^{3/2}}$ x 10^6 $\frac{\text{amps}}{\text{volts}^{3/2}}$	α °	$\frac{I}{V_z^{3/2}}$ x 10^6 $\frac{\text{amps}}{\text{volts}^{3/2}}$
90%	18.5	8.8	71.5	3.0
75%	30	15.3	60	8.8
50%	45	26.5	45	26.5

ally the current can be expressed by the total energy $= V_z + V_\theta$ of the electrons. In this case Equation 7 of the form

$$I = 265 \text{ x } 10^{-6} \frac{\triangle r}{r_0} \sin\alpha \cos^2\alpha \; V^{3/2} . \quad (10)$$

obtain maximum interaction between the beam and an structure, the direction of the electric r.f. field should the same as that of the electronic motion. This condi- is not easy to fulfill. Most existing r.f. structures pro- e an electric field either in the θ-direction or in the irection. In both cases only part of the total energy of electrons can be used for conversion into r.f. power.* If electric field is in the θ-direction, the ratio of usable rgy to total energy is given by

$$V_\theta/V = \cos^2\alpha \qquad (11)$$

for a field in the z-direction by

$$V_z/V = \sin^2\alpha \; . \qquad (12)$$

can easily be seen that in the case of an r.f. field in the direction the angle α should be small. However, ac- ding to Equation 8, α should be large to obtain a high rent. Therefore a compromise must be accepted.

A similar situation exists if the electric r.f. field is in z-direction. For good interaction with the beam, α uld be large (close to $\frac{\pi}{2}$). To obtain a high current, should be small according to Equation 9.

Assuming a certain efficiency V_θ/V or V_z/V, the gle α and the perveance can be calculated from Equa- ns 8, 9, 11 and 12. Table 1 shows the result of this culation for efficiencies 50 per cent, 75 per cent and per cent and $\triangle r/r_o = 0.1$.

As can be seen, for efficiencies higher than 50 per cent, θ-field gives a higher perveance. As $\triangle_r/_{ro} = 0.1$ does not present the upper limit, a perveance of 10 to 20 x 10^{-6} th an efficiency of 90 per cent is entirely feasible. Un- rtunately, all existing r.f. structures for high power vels have their electric fields in the z-direction.

Let us finally have a critical look at Equation 10 which ves the maximum perveance expressed in terms of the al potential V of the electrons. The function sin α $s^2\alpha$ has its maximum at $\alpha = 35.3°$. This means that e electrons have to be injected into the system at a rtain angle in order to obtain the maximum current for given voltage V. If the direction of the r.f. field can be made to coincide with the direction of the electrons, the whole energy of the beam is available for conversion into r.f. energy. The maximum perveance for $\alpha = 35.3°$ is

$$P_{max} = \frac{I}{V^{3/2}} = 102 \text{ x } 10^{-6} \frac{\triangle r}{r_0} \qquad (13)$$

with

$$V = V_z + V_\theta \; .$$

There are various methods of injecting the electrons into the system. In the helitron and in the spiratron a pure electrostatic field is used to impart the necessary velocity components v_θ and v_z to the electrons. In a Harris-flow system a combination of an electric field in the z-direction and a radial magnetic field is employed.

THE HELITRON [9]

Figure 13 shows a pictorial diagram of the helitron, a backward-wave oscillator for the 1.2 to 2.4 kmc frequency range. Similar to the magnetless "magnetron," the inner focusing cylinder is replaced by an r.f. structure. However, in two important points the helitron is different from Versnel's tube. First, the electrons have a velocity component parallel to the axis, providing in this way a repeated interaction with the r.f. structure. Second, the strips which form the r.f. structure are terminated by ohmic resistors. Therefore the circuit is non-resonant and the tube can be tuned electronically over a wide frequency range. The tube is characterized by the following data:

Circuit - cathode voltage	$V_c = 500$ to 1700 volts
Outer cylinder (sole) — cathode voltage	$V_s = 135$ volts
Collector current	$I_c = 0.45$ to 1 ma
Beam transmission	16 to 43%
Perveance	$I_{cath}/V_{beam}^{3/2} \approx 0.1$ to 0.5 x 10^{-6} amps/volt$^{3/2}$
r.f. power	1 to 10 mw

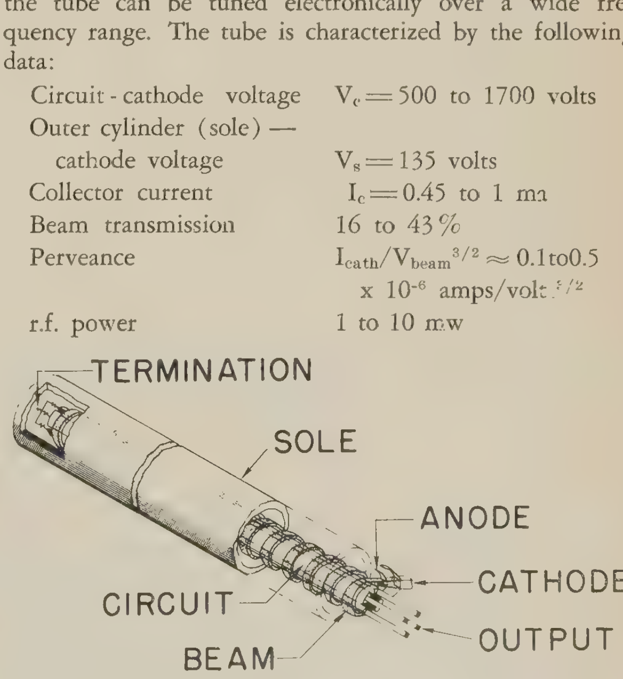


Figure 13 — Pictorial view of the helitron oscillator (courtesy of D. A. Watkins)

Recovering the unused part of the electron energy by slowing down the electrons in a retarding field is possible but hard to realize, especially in the case of rotational energy.

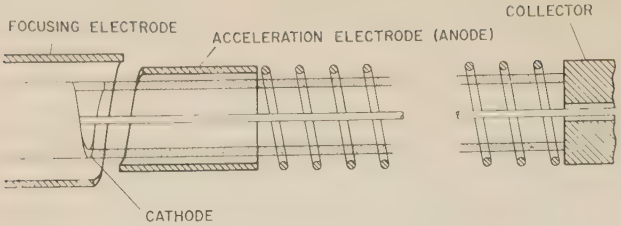


Figure 14 — Cross-section of a spiratron (simplified)

From the electron-optical point of view, the proper injection of the electron beam into the focusing system represents a formidable three-dimensional problem. As yet, none of the existing methods, the electrolytic tank, rubber membrane, or resistor network are able to solve the problem. With an improvement of the entrance conditions for the electron beam the efficiency of the tube, which is now of the order of one per cent, probably could be improved.

THE SPIRATRON [7, 8]

In the Russian spiratron, the electron beam moves between a helix and an inner axial conductor, as shown in Figure 14. The problem of beam injection has been solved in a very elegant manner by specially shaping the ends of the cylindrical cathode, focusing electrode, and anode. The following data were given by Tchernov:

Frequency	f = 1.5 to 2.5 kmc
Voltage of inner electrode	$V_i = 1.8$ kvolts
Helix voltage	$V_h = 1.5$ kvolts
Collector voltage	$V_c = 1.8$ kvolts
Current	I = 25 ma
Output power	$P \approx 10$ to 12.5 w
Efficiency	25 to 30%
Max. beam transmission	98%

If the beam voltage is assumed to be $V_b \approx 1/2\ (V_i + V_h) = 1.65$ kvolts a perveance of 0.37 x 10^{-6} amps/volts$^{3/2}$ can be calculated.

Another spiratron for the frequency range between 3 and 3.75 kmc had an efficiency of 23 per cent with a relatively low current of 6 ma.

An S-band backward wave oscillator using the same focusing method had a tuning range of 20 to 30 per cent if one voltage was changed, and a tuning range of 1 : 2 if two voltages were changed. The r.f. power of this tube was several tens of milliwatts.

HARRIS-FLOW [6, 10]

Figure 15 shows a schematic diagram of Harris' focusing system. An electron gun producing an annular beam is placed in the interior of a magnetic circuit, where the

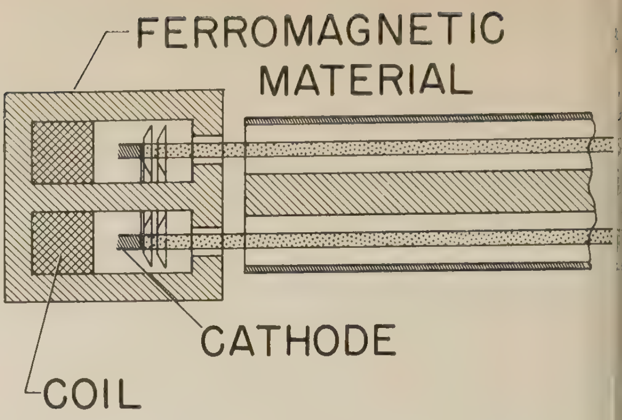


Figure 15 — Focusing system according to Harris.

magnetic field is zero. Leaving the gun, the electrons ha only one velocity component in the z-direction. Wh passing through the radial field in the gap of the ma netic circuit, the electrons are deflected in such a w that the entire beam starts rotating around the axis. T angular velocity $\dot{\theta}$ can be calculated from Busch's theor

$$\dot{\theta} = \frac{e}{m} \frac{\psi}{2\pi r^2}$$

where ψ is the total magnetic flux passing through t beam, and r the distance of an electron from the ax After leaving the magnetic field the electrons enter t electric field between two concentric cylinders, where t focusing action formerly described takes place. The ma mum perveance which can be focused can be calculated a proximately from Equation 10.

In the experiment described by Harris, the beam volta was 1000 volts and the beam current 500 ma. This co responds to a remarkably high value of perveance 16 x 10^{-6} amps/volts$^{3/2}$. The maximum theoretical val calculated from Equation 13 is very close to this figu Without the current intercepted in the gun, the bea transmission of the focusing system was about 60 per cer

A UHF-traveling-wave tube using Harris' method w built by Crumly [10]. The data for this tube are give in the following table:

Frequency	f = 250 to 800 mc
Axial beam voltage	$V_z = 134$ volts
Beam current	I = 5 ma
Perveance	$I/V_z^{3/2} = 3.2$ x 10^{-6} amps/volts$^{3/2}$
Beam transmission	75 to 90%
Max. r.f. power	120 mw
Max. efficiency	12%
Max. small signal gain	G = 18 db

lectromagnetic Properties of
FERRIMAGNETICS AND THEIR APPLICATIONS
From UHF to Millimeter Waves

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LAST OF THREE PARTS

n the preceding sections we have discussed the theoreti- solutions for several types of modes that exist in fer- loaded waveguides and cavities and also the recent ies of the fundamental properties of ferrimagnetic erials, including the nonlinear phenomena. In the er context, such devices as the ferrite harmonic genera- , the ferromagnetic amplifier and the power limiter e been treated. In this concluding installment, Part ree, we shall not try to review all of the miscellaneous elopments of the past few years but rather to deal re completely with three outstanding topics, namely, HF devices, the reciprocal phase shifter and millimeter ve applications. These also represent significant areas interplay between the fundamental developments and realization of practical applications. A number of im- rtant ferrite devices will not have been mentioned in s series. Some of these have been described in detail Bowness and Rizzi.**

. FERRITE DEVICES IN THE UHF BANDS

The development of ferrite components at frequencies low 3000 Mc has appeared to be a rather difficult prob- n. Recently, several developments in both the ferrite terials and the use of the materials in small-guide uctures have overcome many of the apparent difficulties. addition, the use of these newer ferrites and garnets s made possible the development of components which ll tolerate high signal power. Two principal obstacles ve been the large size of rectangular or circular guide mponents (making it difficult to apply an external magnetic field by means of a permanent magnet) and also the insertion loss caused by the ferrite at these low frequencies. The size problem has been alleviated by the development of ferrite nonreciprocal components in coaxial line, stripline and cut-down rectangular waveguide. The insertion loss, which is due to both dielectric and magnetic losses in the ferrite and nonlinear effects at high power, has also been dealt with effectively. The nonlinear effects have been discussed previously. Dielectric losses can be serious at UHF frequencies because the dissipative part of the dielectric constant rises sharply as the frequency is lowered[70]. Thus, attention must be given to the choice and preparation of high-resistivity materials[71].

Low Field Magnetic Losses

The magnetic losses at low power levels arise as a result of the incomplete magnetization of the ferrite in the small applied dc fields that are required for resonance at these low frequencies. Even at 1300 Mc, the performance curves for the resonance isolator[72] shown in Figure 29 indicate that the insertion loss (lower curve) decreases slowly as the magnetic field is increased and the ferrite gradually becomes fully magnetized. This figure also illustrates the difficulty that would be experienced in operating a circulator at L-band if this type of ferrite were used. The nonreciprocal phase shifter element of the circulator would normally be operated at a magnetic field less than that required for resonance, say, at 400 oersteds in Figure 29. In this case, of course, the losses for both directions would be prohibitive.

These "low-field magnetic losses" are more serious at lower frequencies because, theoretically, they can occur for incompletely magnetized material at frequencies up to[73]

$$\omega_{\max} = \gamma(H_A + 4\pi M_s) \qquad (21)$$

where H_A is the anisotropy field and $4\pi M_s$ is the saturation magnetization of the ferrite. This frequency is in the

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Operated with support from the U.S. Army, Navy, and Air Force.

A variety of other ferrite switches, modulators, isolators and circulators designed for operation at L, S, C, X and K bands have been reviewed by C. Bowness, "Microwave Ferrites and their Application," Microwave Journal, vol. 1, No. 1, pp. 13-21; July, 1958 and P. A. Rizzi, "Microwave Properties of Ferrite Rotators," Microwave Journal, vol. 1, No. 3, pp. 26-34; Nov. 1958.

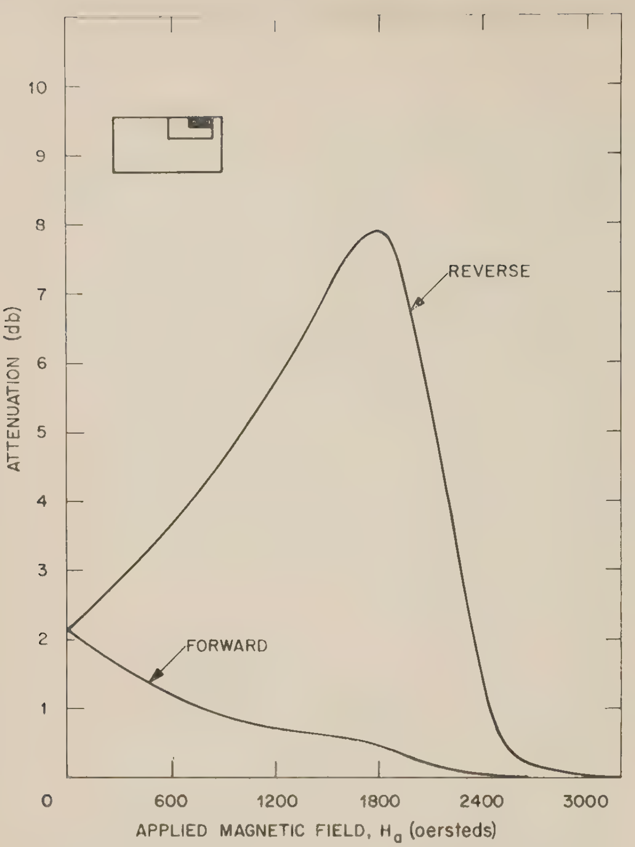

Figure 29 — Reverse and forward attenuation at 1300 Mc for Ferramic R1 in a rectangular waveguide. Low-field losses are large for both directions of propagation. (After Heller and Catuna).

microwave region for most ferrites. Of course, it is sometimes possible to choose a ferrite with a smaller $4\pi M_s$ to reduce ω_{max} below the operating frequency[74]. Figure 30 shows the characteristics of the L-band isolator developed by Heller and Catuna[72] using a material having a value of $4\pi M_s$ about half that used in Figure 29. The resonance line width is narrow as well, which increases the figure of merit, given by[75]

$$R = \alpha_- / \alpha_+ = (4\omega_r/\gamma\Delta H)^2 \qquad (22)$$

UHF Resonance Isolators

The three fundamental problems associated with UHF isolators may be simply defined: First, it is required that the saturation magnetization, $4\pi M_s$, be relatively small to minimize low-field magnetic losses according to Equation 21. Second, one can see from Equation 22 that the smaller the resonance frequency, ω_r, the poorer the performance as measured by the figure of merit R, unless the resonance line width ΔH of the material is correspondingly reduced. Third, if the line width is too small, the isolator will exhibit poor power handling capability because the nonlinear effects set in prematurely (as indicated by Equation 20, Part II).

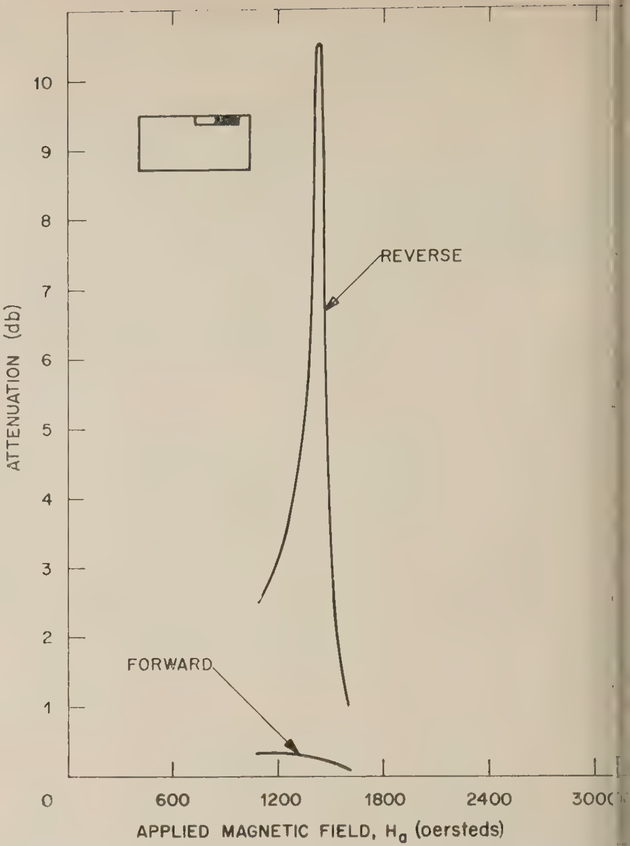

Figure 30 — Reverse and forward attenuation at 1300 Mc fo narrow line-width Mn-Mg ferrite having a saturation m netization of 1160 gauss. (After Heller and Catuna).

One of the most appropriate ferrite materials for high-power, UHF applications is the aluminum-doped nickel ferrite[71]. As aluminum is added[76], the magnetization is sharply reduced, and for $NiO.FeAlO_4$ the magnetization is about 500 gauss*, which is favorable from the point of view of Equations 20 and 21. In addition, as shown[77] Figure 31, at $t = 1$, the line width ΔH is small, whi improves the figure of merit, yet is not sufficiently sm to prevent high power operation. Furthermore, the sig ficance of the smaller value of γ at $t = 1$, shown Figure 31, is not only that it increases the figure of me by a factor of two but also that a proportionately high field is required for resonance at a given frequency a cording to the resonance formula $\omega_r = \gamma H_r$. This high

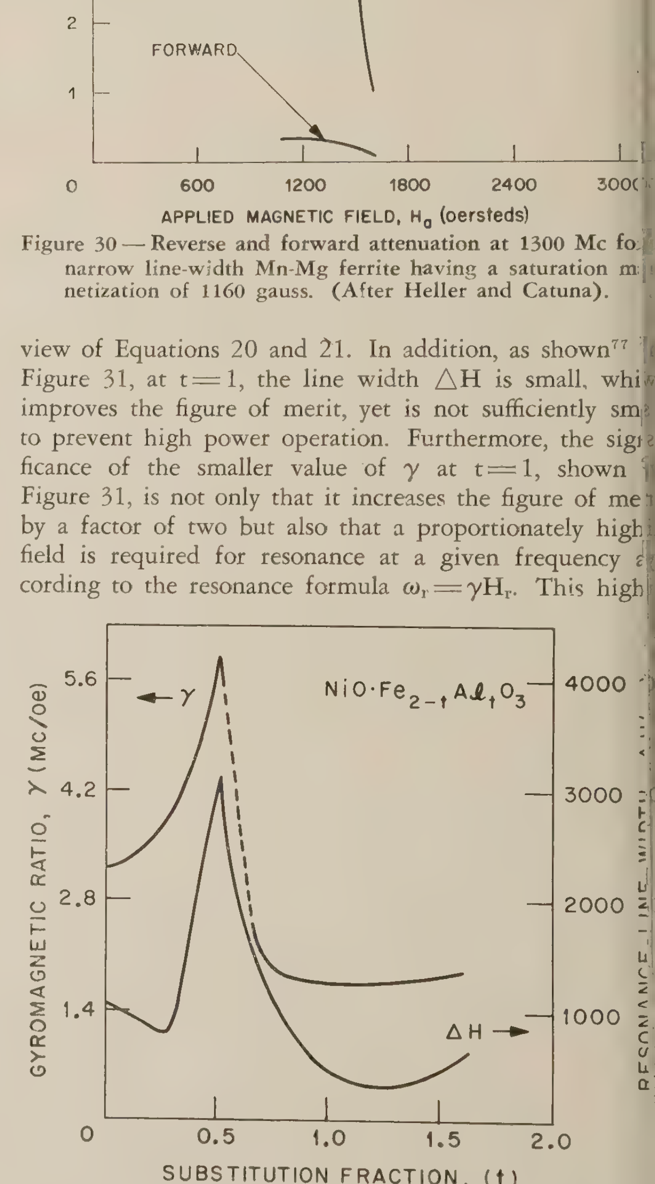

Figure 31 — Gyromagnetic ratio, γ (left scale) and ferroma netic resonance line width, ΔH (right scale) as a fun tion of aluminum substitution for trivalent iron in nick ferrite. Both ΔH and γ are small for $t = 1$, that i $NiO - FeAlO_3$. (After McGuire).

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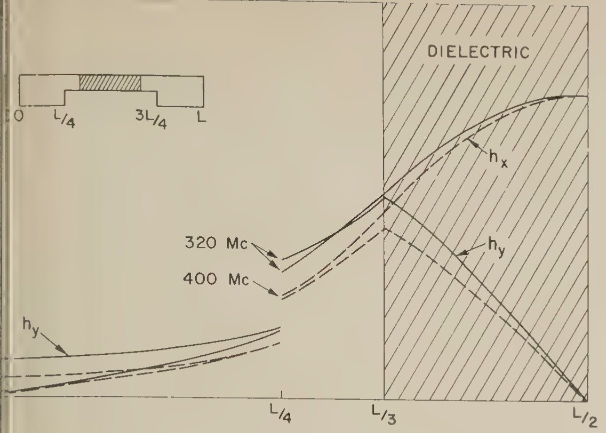
* This principle due to Maxwell and Pickart was illustrated recently in a brief review by K. J. Button, "Historical Sketch of Ferrites and Their Microwave Applications," Microwave Journal, vol. 3, No. 3, pp. 73-79, March 1960.



re 32 — The calculated longitudinal (h_y) and transverse (h_x) microwave magnetic field components in a cut-down single-ridge waveguide containing dielectric at the center, as shown in the inset. Circular polarization ($h_x \simeq h_y$) exists near the dielectric interface for both frequencies. The fields were not matched at the step, L/4, to prevent needless complication. (After Bowness).

serves to magnetize the sample more completely thus cing markedly the low field magnetic losses given by tion 21.

he above principles have been applied to produce L- resonance isolators providing up to 20 db isolation, 1/2 db insertion loss, over a 100 Mc band. They power-handling capabilities up to five kw (av) and Mw (peak). In the 500 Mc band, 10 db isolation has achieved with less than one db insertion loss. Power-ling capacity up to 20 kw (av) and 10 Mw (peak) been attained at 350 Mc over a 50 Mc band.

adband Isolators

he problem of broadbanding the resonance iso-r has been solved at 200 Mc by Bowness[78] at 2000 Mc by Anderson and Hines[79]. Bowness uses ngle ridge rectangular waveguide with dielectric load- at the center. A plot of the transverse and longitudinal nponents of the rf magnetic field (Figure 32) shows a ion of high field intensity and nearly perfect circular arization between the dielectric surface and the wave-de step. These conditions are maintained over a broad quency range because of the concentration of microwave rgy within the dielectric. Bowness has placed a new -magnetization garnet in this region and the isolator vides 10 to 25 db isolation from 200 Mc to 500 Mc h less than one db insertion loss. The isolator is able of handling average power of at least 14 kw.

f the rf fields are concentrated and maintained as a ction of frequency by dielectric loading, the primary blem in broadbanding an isolator is to adjust the field intensity required for resonance at different fre-ncies over the band. This is not difficult at low UHF quencies. For example, the field required for resonance a normally-magnetized flat slab having a magnetization 1000 gauss is 1075 oersteds at 200 Mc and 1175 oer-ls at 500 Mc. This difference of only 100 oersteds is al to a typical half-width of the resonance line. How-r, if the isolator is to operate over the 2000 to 5000 range, the field required at the upper frequency is r 1000 oersteds larger than that at the lower. Anderson Hines[79] have solved this problem by using a tapered field so that some part of the ferrite specimen is in the proper field at any frequency in the 1500 to 6000 Mc band. They independently developed a structure and an analysis similar to that used by Bowness and have achieved 15 db isolation with the remarkably low insertion loss of 0.2 to 0.4 db over the entire range.

The broadband and compact characteristics of coaxial line have been utilized in the design of the coaxial ferrite isolator. Duncan, Swern, Tomiyasu and Hannwacker[80] achieved 20 db isolation over the 2000 to 4000 Mc range in their first demonstration of the coaxial isolator and a similar isolator has been designed by Morgenthaler and Fye[81] to operate in the octave above 500 Mc.

UHF Circulators

Low magnetization ferrites must also be used in UHF phase shifters to avoid low-field losses. Furthermore, the ferrite resonance line width must be small for efficient operation according to the expression for the figure of merit[75]

$$F = 2\omega_r/\gamma\Delta H \qquad (23)$$

Magnesium manganese ferrite doped with aluminum has a substantially narrower resonance line width for $t < 1$ than nickel ferrite-aluminate but the Néel temperature is also much lower[82] rendering it of little value in an absorption isolator. Nevertheless, for $t < 0.65$ ($T_N > 30°C$) it is well-suited for use in low power circulators by virtue of its narrow line width. Arams and Krayer[83] have developed a four-port circulator in cut-down rectangular waveguide which has a 75 Mc bandwidth at 1300 Mc about 0.3 db insertion loss and over 30 db isolation between ports. Since this circulator is used in maser-amplifier systems where the insertion loss must be very low, it is biased with a dc magnetic field above the resonance field to avoid low-field magnetic losses. There is no problem of high-power losses in a receiver application so that the low Néel temperature is not a troublesome factor.

Coaxial ferrite circulators are not yet available in the UHF range although theoretical computations at 2000 Mc[18] and 400 Mc[84] show that sufficient differential phase shift can be obtained for practical values of the design parameters. Rowley[85] has verified the theoretical predictions experimentally with his measurements of differential phase shift in 7/8 inch coaxial line at 2000 Mc. Presum-

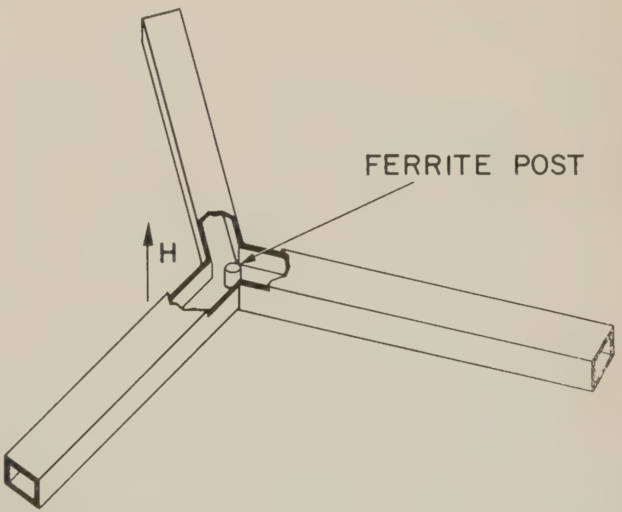


Figure 33 — Y-circulator showing the ferrite post located at the center of the three port junction and transversely magnetized. (After Thaxter and Heller).

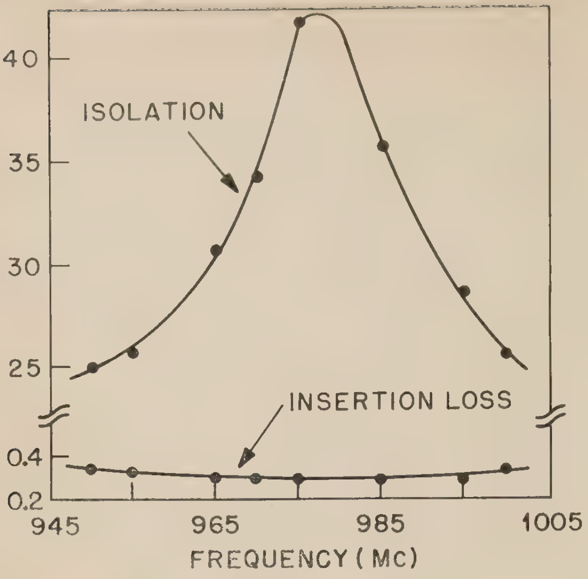


Figure 34 — Isolation between ports and insertion loss (in db) for the L-Band Y-circulator as a function of frequency. (After Davis, Milano and Saunders).

ably, the relative broad band characteristic of this phase shifter would make it attractive for circulator applications.

A particularly compact and easily-constructed device which is now available for the UHF range above 300 Mc is the 3-port Y circulator. The possibility of a three-port circulator was postulated by Carlin[86] on entirely theoretical grounds from the scattering matrix treatment of the three-port microwave junction. The present form of the Y-circulator was first described by Schaug-Pettersen[87] and the analysis of the three-port junction containing a symmetrically-disposed ferrite, as shown in Figure 33, has been given by Fowler.[88]

Although the theory of operation of this device has not been formulated in terms of the local boundary value solution, Heller[89, 90] has stated the general theorem involving the nonreciprocal scattering of electromagnetic radiation. It has been concluded that a matched three-port junction containing a lossless nonreciprocal element will behave as a perfect circulator. The performance characteristics of the Y-circulator at 9300 Mc have been described by Chait and Curry[91] and a particularly compact version was constructed in a stripline junction at 975 Mc by Davis, Milano and Saunders[92]. Typical characteristics of the UHF Y-circulator are shown in Figure 34. Such circulators operate down to 350 Mc providing about 25 db isolation between ports, 0.5 db insertion loss and have a power-handling capacity of five watts (av) and 90 kw (peak). Although, at present, the Y-circulators have a relatively narrow bandwidth, the possibilities of improved geometrical configuration of both ferrite specimens and the microwave junctions may alter this situation.

VII. RECIPROCAL PHASE SHIFTER

Several investigators[93-95] have considered the design of reciprocal phase shifters in waveguides and transmission lines, particularly for antenna scanning and switching applications. The objective is to control large changes in phase at high switching speed by changing the magnetic field intensity applied to the ferrite in the waveguide. One way to accomplish this is to make use of the large change in permeability as a function of dc field at field intensities near ferromagnetic resonance[93]. This has the

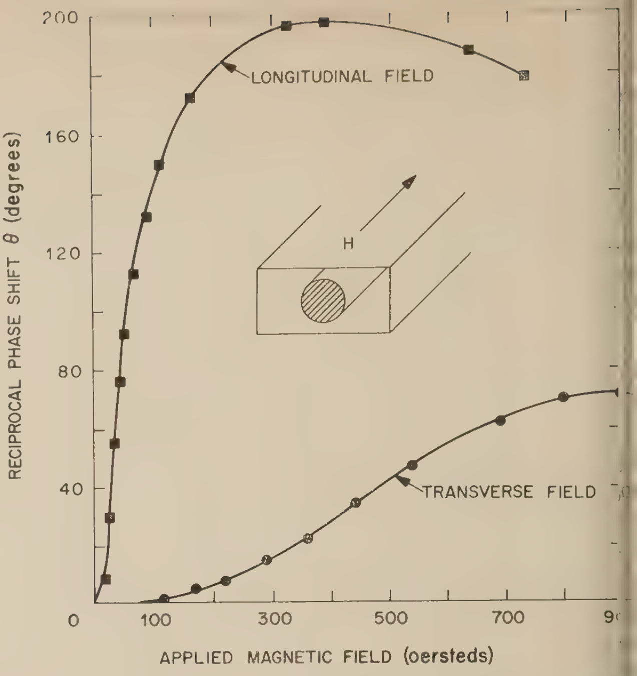


Figure 35 — Comparison of reciprocal phase shift at sm fields for longitudinal magnetization (upper curve a inset) and transverse fields (lower curve) using a ferr rod 2″ long and 0.25″ diameter at the center of the wa guide. (After Bush).

disadvantage, however, that some resonance losses c hardly be avoided in the region where the largest chang in permeability take place. The most practical reciproc phase shifter, which operates with very small magne fields far from resonance, is shown in Figure 35. Th device, first reported by Bush[96] and investigated more e tensively by Reggia and Spencer[97], makes use of the *sm* change in rf permeability that occurs as the ferrite b comes magnetized. If the external dc magnetic field applied to the rod lengthwise where the demagnetizi factor is nearly zero, there is a rapid change in perme bility as shown by the upper curve of Figure 35. If H is applied crosswise (lower curve), the transverse d magnetizing field, $2\pi M$, inhibits the magnetization of t rod as the external field is increased.

The experimental results of Reggia and Spencer, show in Figure 36, have established that the phase shift negligible for ferrite rods of small diameter but increas sharply for rod diameters larger than 0.150 inch standard X-band rectangular guide. This "threshold diam ter" occurs (and has the same numerical value) at a intensities of the applied magnetic field. Since this phen menon is independent of the magnetic field intensity[98], t magnetic properties of the ferrite rod are not responsib for this sharp increase in phase shift as a function diameter. Thus the origin of the phenomenon is a parently an electromagnetic field concentration within t rod (inset of Figure 37) due to the large dielectric co stant ($K_e = 13$) of the ferrite. Above the critical diam ter, the ferrite rod acts essentially as a dielectric wav guide.

Theoretical Analysis

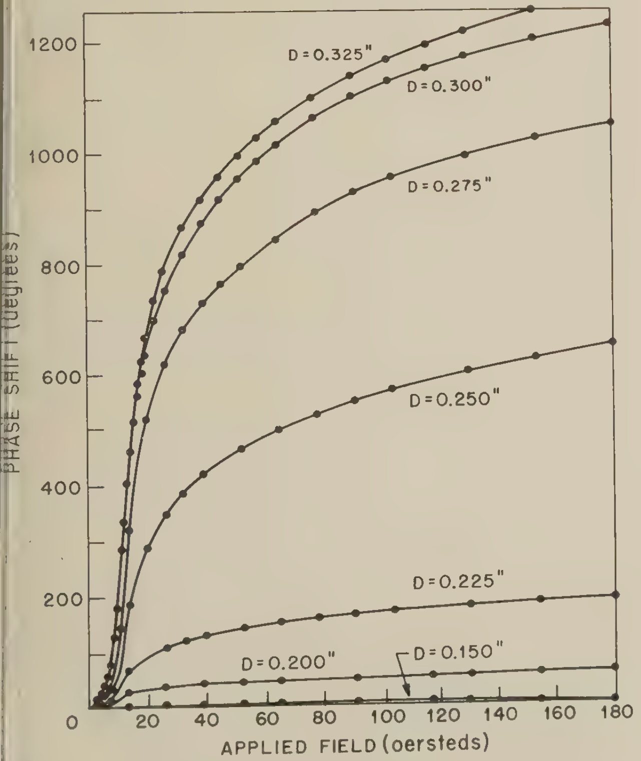
Button and Lax[98] have tested these hypothes quantitatively with the use of perturbation theo in which the physical assumptions outlined abo have been incorporated mathematically. Only the fund ental TE_{10} mode of rectangular waveguide was included the analysis. The rf field patterns to be used in the rturbation formula were derived for an equivalent dictric slab, as shown in the inset of Figure 37, and the nall change in permeability was used as the perturbation. can be shown that the change in permeability is small the ferrite becomes magnetized. Since the rf magnetic ld at the center of the guide is purely transverse, it is ly necessary to evaluate the diagonal component of the fective permeability tensor for a longitudinally magneзed rod

$$_{\mathrm{eff}} = 1 + (\chi_{\mathrm{xx}})_{\mathrm{eff}} = 1 + \frac{\omega_{\mathrm{M}}\,[\omega_{\mathrm{o}} + \omega_{\mathrm{M}}/2]}{\omega_{\mathrm{r}}^2 - \omega^2} \approx 1 - \frac{\omega_{\mathrm{M}}^2}{2\omega^2} \qquad (24)$$

here ω is the operating frequency, $\omega_r << \omega$ is the rromagnetic resonance frequency, $\omega_r = \omega_o + \omega_M/2$ for longitudinally magnetized rod, $\omega_o = \gamma H_o$, $\omega_M = 4\pi M$, and $\omega_M >> \omega_o$. The contribution due to the nall longitudinal component of rf magnetic field at the lges of the slab is zero[99] since this component has odd mmetry about the center. Evaluation of Equation 24 ows that $\Delta\mu = \mu_o - \mu_{\mathrm{eff}} \approx 0.2$ which could only inoduce a small perturbation of the fields in the "ferriteelectric." For cases of practical interest where the rod is rger than the threshold value, the perturbation formula duces to the approximate explicit expression

$$\Delta\beta \approx -\frac{\beta_d}{2}\,\frac{\Delta\mu}{\mu_o} \qquad (25)$$

ere β_d is the phase constant for a rectangular guide conning an equivalent dielectric slab. This approximate sult is applicable in general whether the ferrite is a rod or a slab because the integrals of the perturbation formula are taken over an area. Only the numerical value of β_d is influenced to some extent by the geometry. The large value of β_d compared to the empty waveguide phase constant gives the needed magnification to $\Delta\mu$ in Equation 25 to produce the large phase shift, $\Delta\beta$[100].



igure 36 — Reciprocal phase shift for a longitudinally-magnetized ferrite rod at the center of a rectangular waveguide as a function of applied dc magnetic field with rod diameter as a parameter. The phase shift increases sharply at the threshold thickness of 0.2″ at X-band wavelength. (After Reggia and Spencer).

Although Equation 25 demonstrates the basic principle of operation of the phase shifter, it is not difficult to evaluate the actual perturbation formula numerically. This requires the use of the trigonometric expressions for the components of the rf field patterns of the dielectric loaded guide. The result demonstrates the phenomenon of "threshold diameter" as shown in Figure 37. This result implies that higher-order modes[101], magnetic concentration effects[97] and Faraday rotation[102], not considered in the perturbation analysis, are not involved primarily in producing the large phase shift. A direct quantitative comparison, however, between theoretical and experimental results requires a knowledge of the static magnetization curve for the particular ferrite specimen used in the experiment.

There are a number of practical problems associated with the design of this reciprocal phase shifter, one of which is the hysteresis effect[103]. Some success has been achieved with ferrites having a narrow hysteresis loop[104].

VIII. MILLIMETER WAVE APPLICATIONS

The prospect of developing nonreciprocal ferrite components in the millimeter wave region has always presented some difficulties, particularly at the shorter wavelengths. The fundamental problem is that dc fields of 10 to 100 kilogauss are required for ferromagnetic resonance

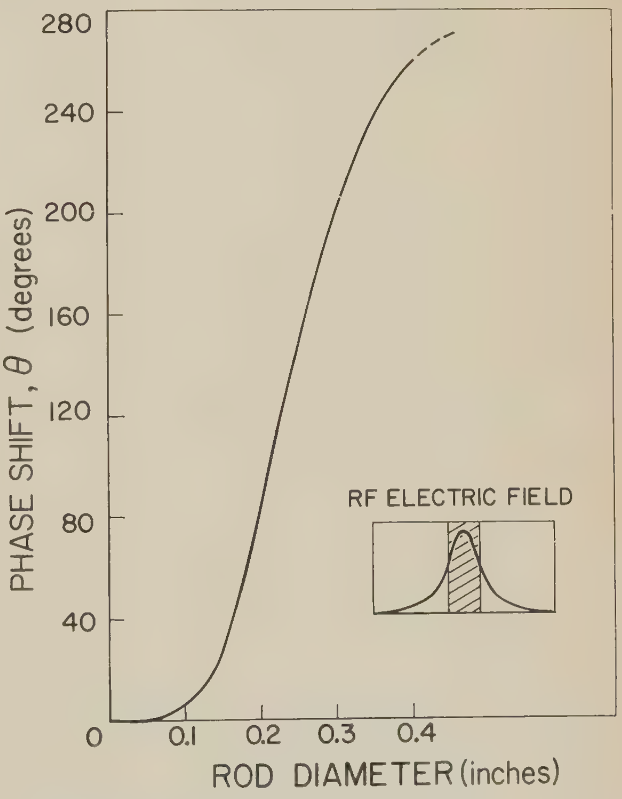


Figure 37 — Theoretical reciprocal phase shift showing the abrupt increase at the "threshold diameter." The complete perturbation formula was evaluated for Bush's phase shifter (Figure 35) and a saturation magnetization of 2500 gauss. The inset shows the rf electric field pattern for the dielectric slab of equivalent area used in the theory. (After Button and Lax).

in this region. It has been possible to provide a ferrite isolator at eight mm where a great deal of development work is being done. The external field of about 10 kilogauss that is required for resonance at eight mm in a long rod or slab can be supplied by an electromagnet or permanent magnet. This approach is not practical for devices at four mm or at higher frequencies although large laboratory electromagnets can achieve fields above 20 kilogauss. One solution to this problem was revealed during Beljers' study of Faraday rotation in Ferroxdure[105] when he pointed out that resonance occurs in the millimeter region in the internal field of this particular type of ferrite material. This is one of a class of uniaxial ferromagnetic materials with hexagonal crystal structure which have large internal anisotropy fields. An oriented pseudo-single crystal of Ferroxdure or Indox V has a built-in anisotropy field of 17,000 gauss and a magnetization of about 5000 gauss. An additional external field of about 8000 gauss is required for resonance at four mm. Indeed, isolators at these wavelengths have been built by Weiss and Dunn[106] and by Kravitz and Heller[107]. A variety of these hexagonal compounds are available with internal anisotropy fields up to 28,000 gauss which should permit isolators to be developed as far as three mm.

Dispersive devices do not present as much difficulty, in principle, because it is only necessary to saturate the sample magnetically to obtain nonreciprocal effects. The actual problem here is that differential phase shift (or Faraday rotation) is inversely proportional to the frequency. Not only does the nonreciprocal effect decrease with increasing frequency but the waveguide also becomes inconveniently small for the construction of conventional Faraday rotators or phase shifters. Nevertheless, with the development of the new Y-type circulator shown in Figure 33, Thaxter and Heller[90] have been able to build satisfactory narrow-band circulators at four mm and two mm. It has not yet been shown that these devices can be extended to higher frequencies with the use of conventional ferrites.

The significant advance which holds the greatest promise for devices in the millimeter and submillimeter region is based on Foner's recent suggestion[108] for the use of the large internal fields of antiferromagnetic materials for nonreciprocal devices. More recent theoretical work by Heller has proved the feasibility of this suggestion. Heller and Stickler[109] have described and demonstrated the principles of operation of antiferromagnetic devices. There are a large number of these crystals which have internal effective fields ranging from 50 to several hundred kilogauss. Thus antiferromagnetic resonance can be achieved at nearly any point in the wavelength range from two mm to a few hundred microns in the far infrared by the choice of the appropriate crystal and the application of a moderate external field. The simplest illustration of the nature of this phenomenon is given by the expressions for the magnetic susceptibilities of an infinite antiferromagnetic medium for the two counter-rotating circularly polarized components of a plane wave. If an external field, H_o, is applied along the direction of the internal anisotropy field, H_A, it can be shown that

$$x'_{\pm} = \frac{2\omega_A \omega_M}{(\omega \mp \omega_1)(\omega \pm \omega_2)} \qquad (26)$$

where $\omega_{1,2} \approx \gamma\sqrt{2H_AH_E} \pm \omega_c$.

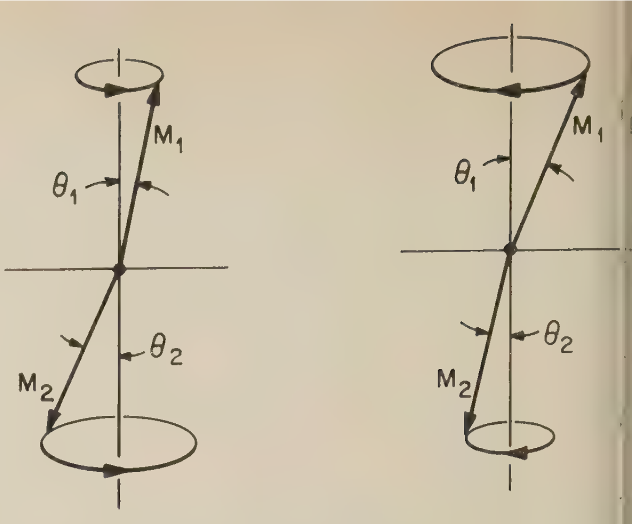


Figure 38 — The two normal modes of precession of t coupled antiparallel magnetic sublattices.

The two resonance frequencies ω_1 and ω_2 may be a tributed to the two different modes of precession of th two coupled antiparallel magnetic sublattices of the m terial[110] as shown in Figure 38. H_E is the internal e change field which is much larger than the anisotro field H_A and ω_o, ω_A and ω_M are equal to γH γH_A and $\gamma(4\pi M)$. We shall also define $\omega_i =$ $\gamma(2H_AH_E)^{1/2}$ as the internal resonance frequency in th absence of an applied magnetic field. At a given value the applied field and frequency in Equation 26, one mo of circular polarization is at resonance while the oth mode is not. We can evaluate the possibility of co structing a resonance isolator based on this principle b computing the figure of merit R which is the ratio of th reverse-to-forward attenuation. The dissipative part of th susceptibility on resonance is

$$x''_{+} = \frac{2\omega_M(\omega_A^2 + \omega_i^2)}{\frac{4}{\gamma T}(\omega_A + \omega_E)^2}$$

(27

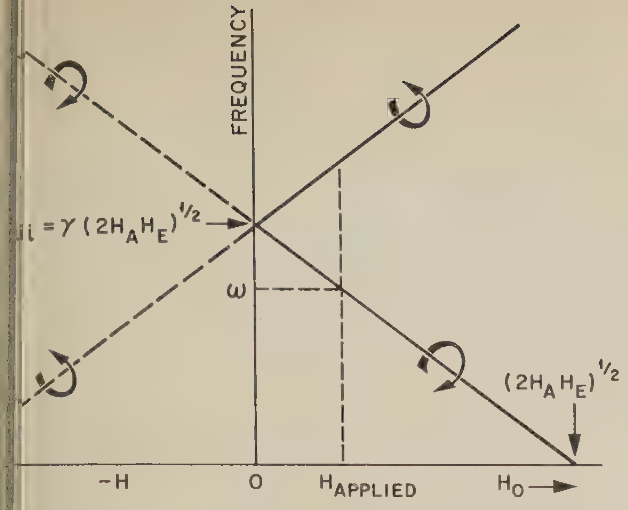
$$x''_{-} \approx \frac{2\omega_M(\omega_A^2 + \omega_i^2)}{(4\omega_o\omega_i)^2\,\gamma T}$$

where T is a phenomenological relaxation time related t the resonance line width. x''_{+} is larger than unity fo Cr_2O_3, for example, and exceeds that of any ferrite a these frequencies. The figure of merit for a resonance iso lator which has been derived by Heller follows directl from Equation 27

$$R = x''_{+} / x''_{-} = (4H_o/\triangle H)^2 \qquad (28$$

Thus we see that the larger the applied magnetic fiel the larger the reverse-to-forward ratio of attenuation. Fo a reasonable field of 7500 to 9000 oersteds and the lin width of 1500 oersteds for Cr_2O_3, the theoretical figure c merit is of the order of 400 which is altogether practic for a resonance isolator at two mm.

The dispersive effect is also comparably large near res nance so that phase shifters or circulators may also be buil using antiferromagnetic materials. For the sake of illus tration and for computing the figure of merit, let us as sume that the operating frequency is at or very near th



ure 39 — Plot of the resonant frequencies ω_1 and ω_2 as a function of applied field for an antiferromagnetic substance.

rnal resonance ω_i. Then the applied field serves to une both modes of polarization, one on either side of nance where the losses are small. Under these cir-nstances, the dispersive part of the susceptibilities are

$$x'_{\mp} = \frac{2\omega_M\omega_A}{\omega_i^2 - (\omega \pm \omega_0)^2} \qquad (29)$$

e figure of merit of a phase shifter is defined as the o of the differential phase shift, $(\beta_+ - \beta_-)/2$ to the nuation, $\propto$, and according to Heller becomes:

$$F = \frac{\beta_+ - \beta_-}{2\propto} = \frac{x'_+ - x'_-}{2x''} = 2H_0/\triangle H \qquad (30)$$

e figure of merit of both the isolator and the phase fter depends on the same parameters, the applied mag-ic field H_0 and the antiferromagnetic resonance line dth $\triangle H$. For the same values used in the previous amples, F is of the order of 10 which is sufficiently large practical devices. We could expect larger figures of rit from narrower line-width materials, such as hF_2 ($\triangle H \approx 250$ oersteds)[105] but this material would ve to be operated at a temperature below that of liquid rogen.

The operating condition of the antiferromagnetic reso-nce isolator is only slightly different from that of the persive devices. The operating frequency, ω, of the lator is chosen near to but not at the zero-field resonance as shown in Figure 39. The figure shows a plot of the two resonant frequencies ω_1 and ω_2 as a function of applied field. The two frequencies respond resonantly to the two modes of circular polarization as indicated in the diagram. Then for an operating frequency less than ω_i, one mode is tuned to resonance by the applied field. The resonant frequency of the other mode is above ω_i. The susceptibility of the isolator on resonance is given by Equation 27 which has a value comparable to Ferroxdure at two mm. The performance of a preliminary experimental isolator constructed by Heller and Stickler[109] is shown in Figure 40 where no attempt has yet been made to achieve the theoretical limit of performance given by the figure of merit.

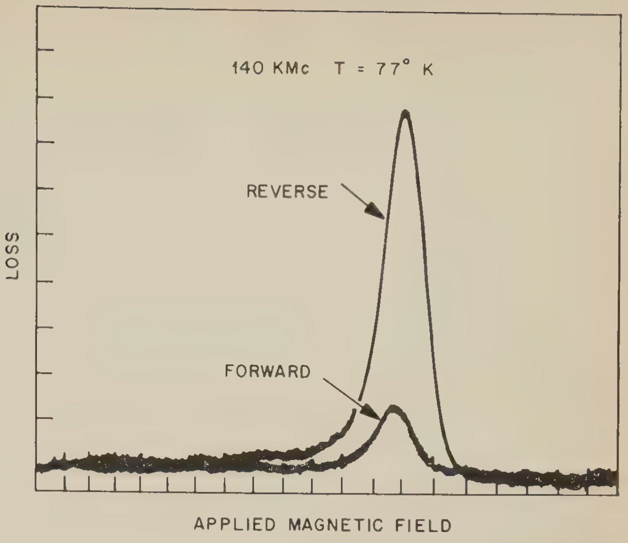


Figure 40 — Preliminary experimental results for the antiferromagnetic resonance isolator operating at 2 millimeter wavelength. (After Heller and Stickler).

ACKNOWLEDGEMENTS

We are greatly indebted to Dr. Gerald S. Heller for permitting us to use some of the results of his research on antiferromagnetic resonance and applications at millimeter wavelengths prior to publication. We wish to thank Dr. Colin Bowness and Dr. Max T. Weiss for making available current performance specifications of UHF and microwave devices and also those who have given us permission to reproduce their illustrations. We are grateful to J. E. Soares for the preparation of the manuscript and illustrations.

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ethods of Automatic
ANALYSIS AND SYNTHESIS
Of Polarization
Of Electromagnetic Waves

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INTRODUCTION

The polarization of electromagnetic waves received by electronic system may be random, variable, or unknown, ticularly if the source of the waves is "uncooperative." order for an antenna to receive maximum possible wer from such an electromagnetic wave, its polarization racteristics must be identical to those of the incident ve. Also, if communications are involved between two ctromagnetic systems, optimum coupling is ordinarily ained if the transmitted waves have polarization pro- rties identical to those of the received waves.

The trace of the electric field vector of an electromag- tic wave defines its polarization. Polarization is usually ear, circular or elliptically polarized, where the first two e special cases of the latter. If a wave is elliptically larized, the electric field vector, which lies in a plane rpendicular to the direction of propagation, traces out elliptical helix in space. If the "helix" is wound in the ection of a right-hand screw thread, the sense of polari- ion is right handed. The opposite direction of rotation aracterizes left-handed polarization. The ratio of the nor to the major axis of the elliptical cross-section of e "helix" defines the axial ratio, and the orientation of e major elliptical axis with respect to some reference de- es the polarization orientation angle. These three: sense rotation, axial ratio, and polarization orientation angle, e the polarization properties of an electromagnetic wave ee Figure 1). Any electronic system which incorporates mplete polarization analysis and synthesis must de- rmine these properties of an incident wave and repro- ce them in the antennas of the system.

evious History of Polarization Analysis and Synthesis

Early attempts by system designers to achieve maximum upling between two electromagnetic systems, where the larization of one is unknown, generally involved using ceiving and transmitting antennas whose polarizations re either linear at a 45-degree orientation angle or cir- lar. The former couples with three-db loss to horizontal rtical, or circular polarization, whereas the latter couples th three-db loss to any linear polarization. Since a fixed larization was used in the antennas, infinite loss was ssible for some one polarization of the incident wave.

To provide tighter coupling between two remote electromagnetic systems and to analyze incoming wave polarizations, certain investigators have developed more sophisticated systems, chiefly in the field of radio astronomy.[1-6] These researchers have been concerned with the resolving of polarization of incoming waves from such phenomena as sun bursts into their correlated and uncorrelated components. However, certain additional features have been considered here, namely, broad frequency coverage, use with space and frequency scan, and polarization analysis of a short-burst of signal. These are generally not important in radio astronomy where frequency and spatial position of the remote signal source are relatively well known and fixed. Among the applications which require the additional features are tracking and jamming or communicating with a space vehicle.

II. ANALYSIS AND SYNTHESIS

The following paragraphs explain certain terms needed later.

Coupling

Use is made of the term "coupling." Coupling with reference to antenna systems is defined as the fraction of maximum possible power from a given transmitting antenna that can be inserted through the receiving antenna

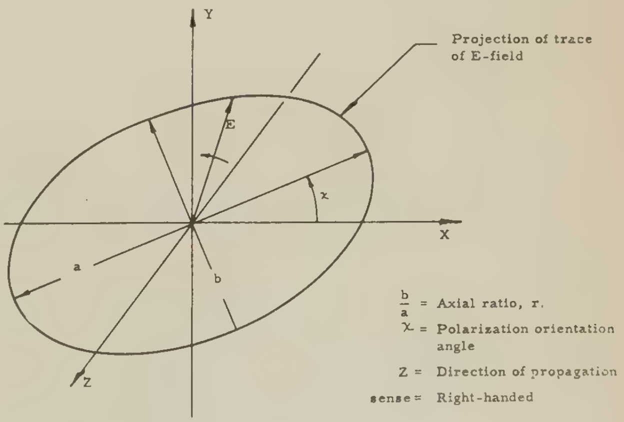

Y
Projection of trace of E-field
E
χ
X
a
b
Z
b/a = Axial ratio, r.
χ = Polarization orientation angle
Z = Direction of propagation
sense = Right-handed

Figure 1 — Polarization Ellipse.

of a remote electromagnetic system. If the polarization of the transmitting antenna is exactly that of the receiving antenna of the remote system, maximum coupling (100 per cent or 0 db) is obtained. Coupling may be less than 100 per cent (less than 0 db) because of errors in analyzing the incoming wave or because of incomplete synthesis of polarization in the transmitting or tracking antennas.

The Faraday effect is ignored, i.e., non-reciprocal rotation of polarization of the "free" space wave due to the earth's magnetic field and the presence of ions in space. Present state of the art makes it impossible to predetermine Faraday rotation at radio or microwave frequencies.[1, 2, 7] This effect is important if two-way communications or jamming is the application involved.

Polarization Parameters

Complete polarization analysis and synthesis requires determination and reproduction of all three polarization properties.[8] These properties may be defined implicitly rather than explicitly by any of the following:

a) The magnitudes of two orthogonal linearly polarized components of the wave and the phase angle between them.[9]

b) A right circularly polarized component, a left circularly polarized component and the phase angle between the two.[10-13]

c) The Stokes parameters, used frequently in radio astronomy polarization measurements.[14, 15] These parameters can be used to measure the unpolarized as well as the polarized components of an electromagnetic wave.

Instantaneous and Non-instantaneous Analysis

Methods of polarization analysis fall into two general categories: instantaneous analysis and non-instantaneous analysis. The former method is one in which the properties of the wave can be determined instantaneously. For example, this category would provide the polarization analysis of a single incoming pulse. This is difficult to achieve if complete analysis over a large frequency spectrum is required.

The non-instantaneous category implies that certain portions of the system may be rotated, searched, tracked, or sampled by either mechanical or electrical methods to obtain polarization information. In general, this engenders a simpler circuit than instantaneous analysis, but is restricted in the generality of signals analyzed.

The method of analysis used in a particular application is largely dependent on whether the signals encountered are expected to be continuous wave or pulse. In some cases it is possible to integrate or stretch a pulse-type signal and use methods of analysis ordinarily suitable only for CW signals.

Partial Analysis and Synthesis

A decision on the degree of polarization analysis that should be provided frequently depends on economic as well as technical and tactical factors. A reduction in circuit complexity can be achieved if the requirement of complete analysis is relaxed. If such a compromise is permitted, it is relatively easy, for example, to provide a system which tracks or transmits with a linearly polarized antenna whose polarization is always aligned with the major axis of the polarization ellipse of the incident wave. This system is not "blind" to any polarization. In fact, the coupling factor will always be 50 per cent or larger.

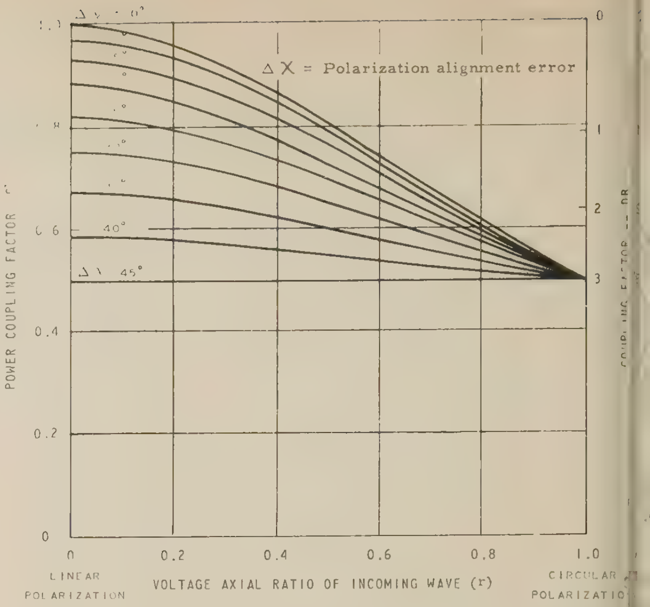


Figure 2 — Coupling factor of a linearly polarized antenna fo various polarization alignment errors as a function of th axial ratio of the incoming wave.

Alignment of the polarization of such a transmitting antenna can be accomplished by mechanical or electronic rotation. The analysis problem reduces to that of determining the polarization orientation angle of the incomin wave since axial ratio and sense of polarization are of n consequence.

Orientation angle is easiest to determine if the incomin wave has a small axial ratio (almost linearly polarized However, maximum deterioration in coupling due to errors in alignment of the synthesized polarization orientation angle also occurs when the incoming wave is nearly linearly polarized. This is shown in Figure 2, which shows

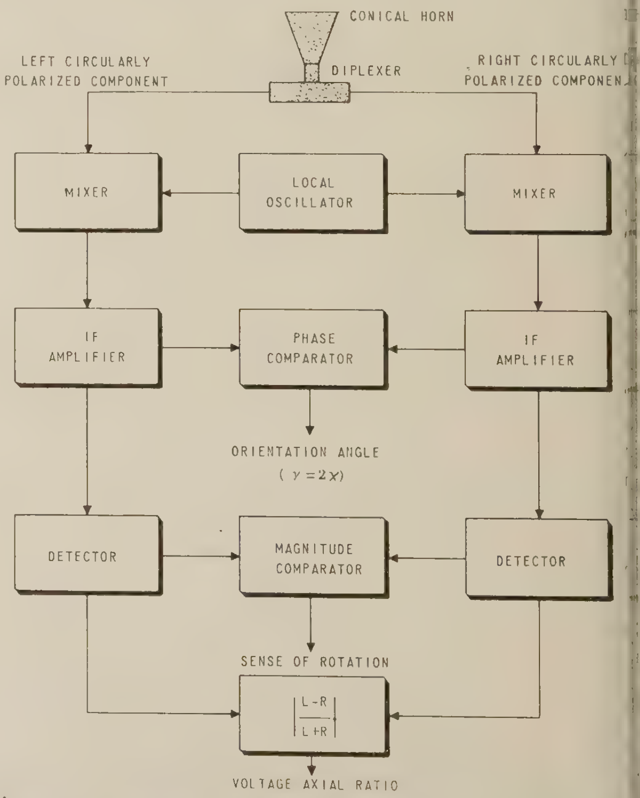
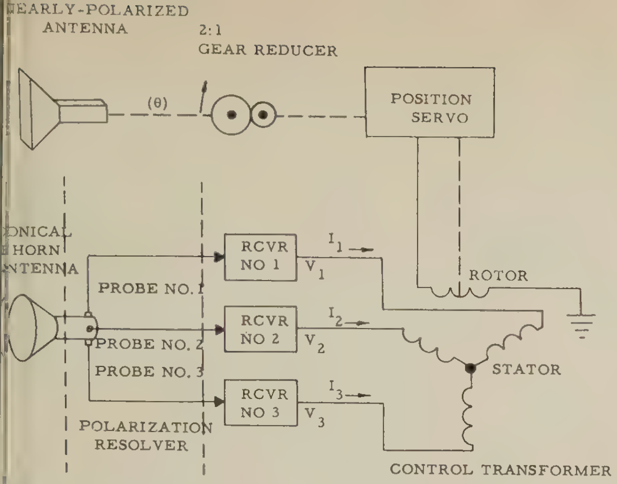


Figure 3 — Complete polarization analysis system which separates and compares the circularly polarized components o an incident wave.



gure 4 — Analog system for synthesis of polarization orientation angle.

upling of a linearly polarized antenna to electromagnetic ves of any axial ratio for various polarization alignment ors. The formulas used for deriving the curves of gure 2 are given in reference (12). It is evident from gure 2 that polarization alignment errors as large as 45 grees result in a minimum coupling factor of 0.5 re-dless of the axial ratio of the incoming signal. This rresponds to only a three db loss of signal.

. METHODS OF POLARIZATION ANALYSIS AND SYNTHESIS REPORTED

In this paper some satisfactory methods of achieving larization analysis and synthesis will be described which tail both complete and partial analysis and synthesis. perimental models have been constructed which suc-ssfully demonstrated two of these methods. Operation of ese models is reported. Broad frequency bandwidth has en a design objective.

omplete Analysis Method

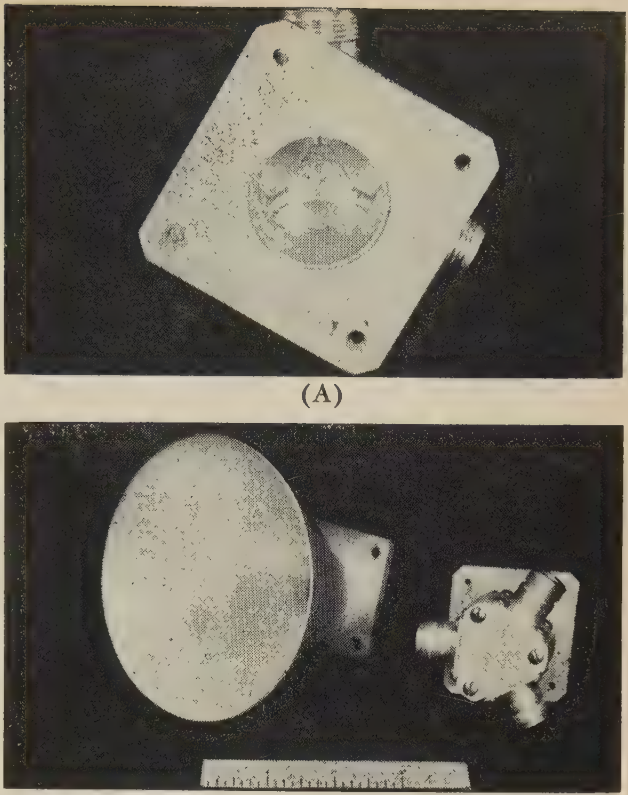
One means of accomplishing complete polarization alysis and synthesis involves measurement of the in-nsity of the right and left circularly polarized compo-ents of the incoming wave and the phase angle between em. This system is shown in Figure 3.

A conical horn receives signals of any polarization. The tached diplexer, which contains a quarter wave plate rcular polarizing section, separates the right and left cir-larly polarized components of the received signal and rects these components to indepedent rectangular wave-uides. Then, a phase and magnitude comparison is made f them. The polarization orientation angle of the original gnal is one half the phase angle difference between these omponents.[10] The difference in the magnitude divided y their sum is the axial ratio of the incoming signal and he sense of rotation is the same as that of the compo-ent having the largest magnitude. Thus, direct measures f parameters which uniquely determine the polarization roperties of an incoming wave are available for recording r use in synthesis of polarization.

artial Analysis Methods

In applications where coupling losses are not especially ritical, partial polarization analysis and synthesis is ade-uate. Some methods of accomplishing this are described elow.

ethod Using Analog Techniques — One method for determining the orientation angle only of the major axis of the polarization ellipse employs analog techniques. Figure 4 shows a block diagram for this system. An arbitrarily polarized wave is incident on a conical horn antenna. Linearly polarized components of this wave whose orientations are separated by 60 degrees are coupled from the horn by means of a polarization resolver (Figure 5). The coupling probes of the polarization resolver are connected to three identical receivers. Here, after preamplification, the signals are rectified, chopped at a 60-cycle rate, amplified linearly and connected to the three stator windings of a control transformer. The synchro control transformer is the analog computing element for this system. The resulting currents in the stator windings produce a magnetic field with orientation and strength dependent upon the magnitudes of the three voltages from the receivers. This magnetic field induces a voltage in the rotor of the control transformer which is proportional to the sine of the angle between the rotor orientation and the resultant stator magnetic field. This generates an error signal which operates a servo motor. The servo motor, mechanically coupled to the rotor, turns until zero error signal is obtained. The angular position of the output shaft of the servo motor is thus proportional to the polarization orientation angle of the incoming signal. A linearly polarized horn connected to this shaft is consequently continuously aligned in polarization with the polarization orientation angle of the incoming wave.


(A)

(B)

Figure 5 — (a) Front view of polarization resolver showing probes.
(b) Conical feed horn and rear view of polarization resolver.

The detailed operation of this system can best be described by considering the analysis and synthesis of a linearly polarized incoming wave. The relative output voltages of the polarization resolver probes are then rectified sine waves. These are proportional to the three stator windings

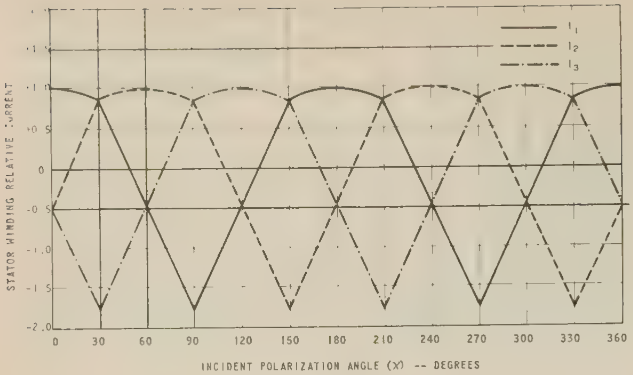


Figure 6 — Calculated currents in torque generator as a function of polarization angle for a linearly-polarized wave incident on the resolver.

of the control transformer. The currents, I_1, I_2, and I_3, in the three stator windings can be obtained from the following expressions:

$$I_1 = \frac{2V_1 - V_2 - V_3}{3Z}$$

$$I_2 = \frac{2V_2 - V_3 - V_1}{3Z}$$

$$I_3 = \frac{2V_3 - V_1 - V_2}{3Z}$$

Where V_1, V_2, and V_3 are proportional to the output voltages of the polarization probes. Z is the impedance of each stator winding circuit including the receiver output impedance. These currents are shown in Figure 6. The break points in the curves are caused by corresponding discontinuities in probe or receiver output voltage at zero output.

The magnetic fields corresponding to each of the stator currents may be represented as vectors with proper space orientations, i.e., with 120-degree angular separations. The sum of these three vectors represents the magnitude and direction of the resulting magnetic field in the stator.

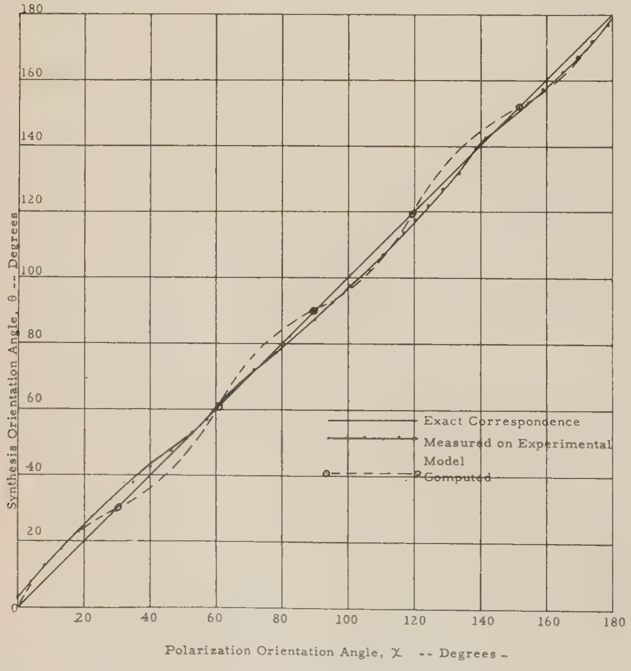


Figure 7 — Synthesized polarization orientation angle on experimental model of analog method of polarization analysis and synthesis with linearly polarized incident wave.

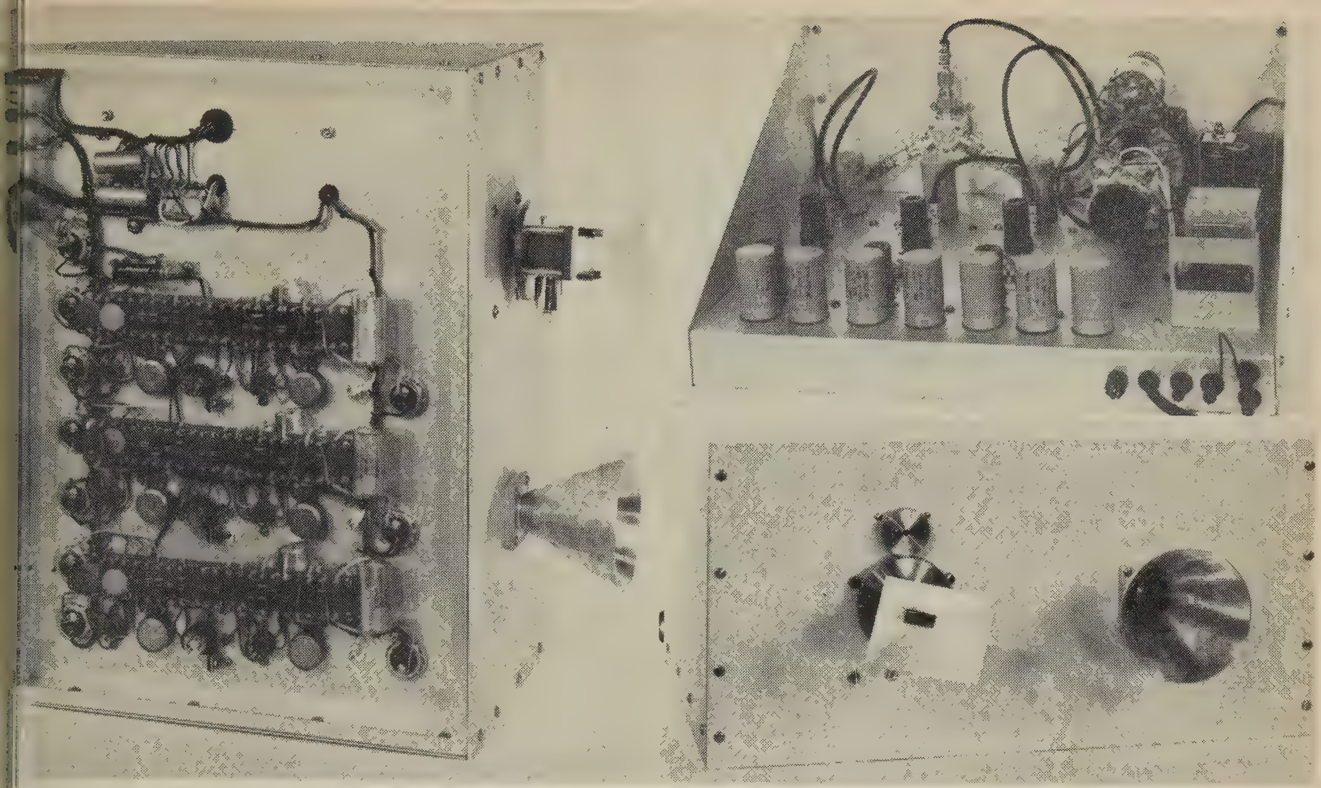
Figure 6 shows that the currents repeat for each 18 degree change in the polarization orientation angle; co sequently, the angular position information conveyed the rotor of the control transformer to the servo motor twice the angular change in the polarization angle. Th is inherent in the amplitude-comparison methods in whic sense or phase of the probe voltage is not preserve Therefore, a two-to-one gear reduction at the servo moto shaft is necessary to provide an angular position, θ, co responding to the polarization orientation angle x. computed from the currents in Figure 6 and the theoret cal induced voltage in the rotor is shown as a function the polarization angle x, in Figure 7. This computed curv shows that exact correspondence between θ and x do not exist even theoretically but that an error of up ± five degrees is to be expected.

Experimental Model of the Analog Method — An e perimental model of the analog method of polarizati analysis and synthesis was constructed and evaluate Photographs of the front, back, and bottom views of t model are shown in Figure 8. The conical receiving ho is attached to the polarization resolver. The linear polarized pyramidal synthesis horn is mounted on a ge stepped up by a factor of two from the gear on the ou put shaft of the servo. In the middle picture, the bac end of the polarization resolver can be seen with cryst detectors containing matched 1N21C crystals connecte to each of the three probe outputs. The control tran former, servo amplifier and servo motor which turn th linearly polarized horn are also visible in this photograp In the bottom picture three terminal strips can be see Each of these contains the appropriate circuits for r ceiving and processing the signal from the polarizatio resolver which corresponds to one of the three line polarization components of the incident wave.

A circuit diagram of these receiver channels is shown i Figure 9. The low level received signal from each of th crystal detectors attached to the polarization resolver ou puts is connected to one of the three input terminals c the receiver channels. Each channel consists of a prea plifier, a rectifier, an R-C filter, a chopper and anothe amplifier. The preamplifier increases the level of the inpu signal which is then rectified and filtered. The resultin d.c. voltage of each channel is proportional to the linea component of the incoming wave as received by the co responding probe of the polarization resolver. A choppe transforms the d.c. signal into a 60 cps square wave whic is then amplified. The final output is applied to a delt network formed by the three stator windings of th Synchro Control transformer in parallel with three capaci tors whose function is to tune the Synchro windings t resonance at 60 cycles. This provides maximum respons at 60 cycles while attenuating harmonics in the choppe waveform.

Experiments were conducted at X-band using an X-1 klystron modulated by a 1000-cycle square wave as signal source. This wave was transmitted by a linearl polarized antenna whose polarization was rotatable an received by the conical horn attached to the polarizatio resolver.

Gains of the three receiver channels were adjusted t provide as close alignment of polarization as possible a one polarization orientation angle of the received signal At all other received signal polarization orientations, th synthesized polarization automatically aligned to withi

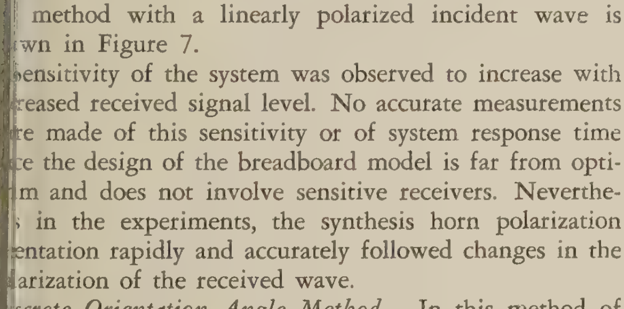


.re 8 — Bottom (left), rear (top right), and front views of experimental model of polarization analysis and synthesis method using analog techniques.

roximately ± five degrees as predicted. The measured nment angles of the experimental model of the ana- method with a linearly polarized incident wave is wn in Figure 7.

ensitivity of the system was observed to increase with eased received signal level. No accurate measurements e made of this sensitivity or of system response time e the design of the breadboard model is far from opti- m and does not involve sensitive receivers. Neverthe- in the experiments, the synthesis horn polarization entation rapidly and accurately followed changes in the arization of the received wave.

screte Orientation Angle Method — In this method of arization analysis and synthesis the coupling factor is npromised to a greater extent than in the other methods scribed since the polarization orientation angle is de- mined only to within a certain angular sector. Polariza- n analysis here simply consists of the detection and nparison of three linearly polarized components of the oming wave, each component being separated in orien- ion angle by 60 degrees. The polarization of a linearly larized synthesis antenna is then aligned with the component having the largest magnitude. A maximum alignment error of 30 degrees is therefore possible between the major axis of the polarization ellipse of the incoming wave and the polarization of the synthesis antenna. This occurs when the axis of the ellipse is midway between two of the linearly polarized detector orientations. Reference is again made to Figure 2 where it is shown that the minimum coupling factor for a 30-degree alignment error varies from 0.75, if the incoming wave is linearly polarized, to 0.5 if the incoming wave is circularly polarized. In other words, the coupling factor is reduced at most by 1.2 db from that which would be obtained by exact alignment.


22 K
Channel 1
+ 300V DC
25µf 450V
100K
12AX7
390K
100K
TP
10K
100K
1µf
470Ω 2W
12AU7
10K 2W
2µf
To S1
.01 µf
DR321
Output 1
.07µf
250K
330Ω
200K 1/2W
10µf 450V
90Ω
50K
500K
270Ω
50K 1 2W
25µf
450Ω
68µf
6.3 VAC
.68µf
To S2
Output 2
To S3
Output 3
Channel 2 (same as 1)
Channel 3 (same as 1)

All resistors one watt, capacitors 600 volt, unless otherwise indicated.

ure 9 — Circuit diagram for receiver of prototype models of polarization analysis and synthesis.

Figure 10 shows a block diagram of this system. An arbitrarily polarized signal is incident on the conical horn. The attached polarization resolver, described earlier, detects the linearly polarized components of this wave whose orientations are separated by 60 degrees at probes No. 1, No. 2, and No. 3. The amplitude comparator then determines which resolver probe orientation is most closely aligned with the polarization orientation angle of the incoming wave by selecting the detected signal with the largest magnitude. The amplitude comparator controls a three-position switch, one position corresponding to each

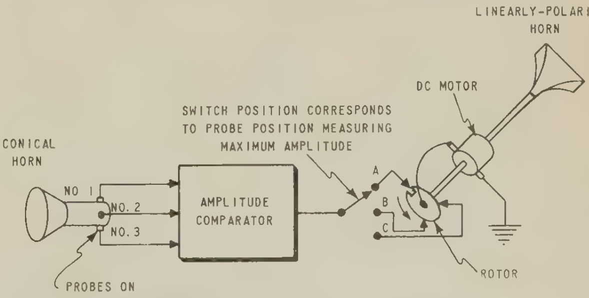

LINEARLY-POLARIZED HORN
DC MOTOR
SWITCH POSITION CORRESPONDS TO PROBE POSITION MEASURING MAXIMUM AMPLITUDE
CONICAL HORN
NO 1
NO. 2
NO. 3
AMPLITUDE COMPARATOR
A
B
C
ROTOR
PROBES ON POLARIZATION RESOLVER

Figure 10 — System using the discrete orientation angle method of polarization analysis and synthesis.

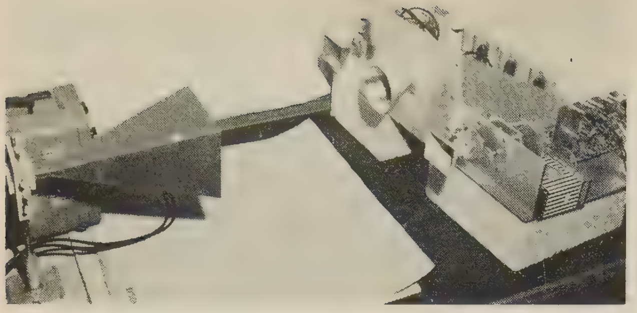


Figure 11 — Experimental model and test set-up of polarization analysis and synthesis using discrete orientation angle method. Front end circuitry of analog model is being utilized.

probe of the polarization resolver. Voltage is applied by the comparator to the switch position corresponding to the probe having maximum amplitude (position A in Figure 10). This voltage is applied to a dc motor through a slotted, rotatable slip-ring to which the motor is also connected mechanically. Thus, when voltage is applied to one of the terminals of the switch, the motor operates and turns the slotted disc until the slot indexes to the corresponding brush position. Voltage is automatically disconnected from the motor at this position and the motor stops. The synthesis horn is mechanically slaved to the motor so alignment of the horn to the orientation of the maximum signal probe is accomplished automatically. This adjusts polarization to a position that is within 30 degrees of the polarization orientation angle of the incident wave. When the polarization of the incoming wave changes so that maximum signal is received by a different probe, the comparator applies voltage to a new switch position. This again results in voltage being applied across the motor causing it to turn and rotate the disc. When the slot in the disc is rotated to the new brush position, voltage is again disconnected from the motor and the linear antenna is oriented to within 30 degrees of the new polarization orientation angle.

Modification of Discrete Orientation Angle Method — A modification of this method can provide alignment to within 15 degrees of the polarization orientation angle of the incident wave by comparing the amplitudes in the two probes of the polarization resolver having the smaller amplitudes of received signal in addition to determining which probe has the largest amplitude. Polarization alignment is then adjusted 15 degrees to one side or the other of the probe receiving maximum signal. A block diagram of this system is the same as Figure 10 except that the amplitude comparator controls a different switching arrangement and the motor has six equally spaced stopping positions instead of three. A maximum alignment error of 15 degrees is theoretically possible with this method. Figure 2 shows that this corresponds to a coupling factor of 0.933 for a linearly polarized incident wave compared to 1.0 if perfect alignment is attained, whereas a 30-degree alignment error corresponds to 0.75 under the same conditions.

Experimental Model of Discrete Orientation Angle Method — An experimental model of the six-position discrete orientation angle method has been constructed and evaluated and is shown in Figure 11. The polarization resolver

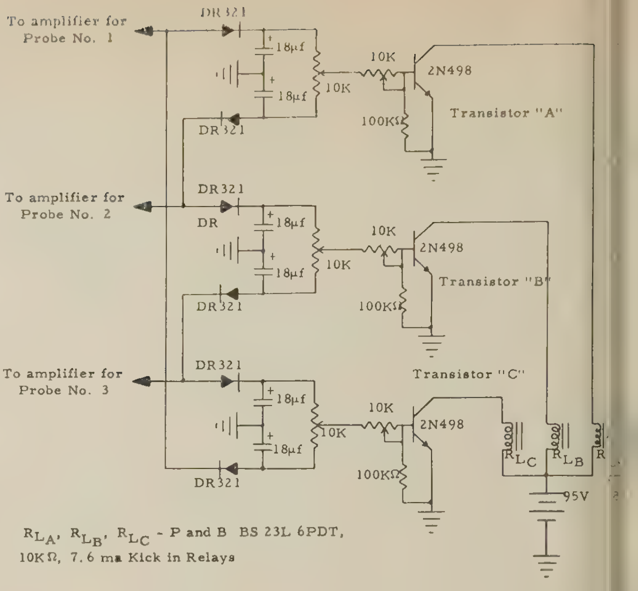

To amplifier for Probe No. 1
To amplifier for Probe No. 2
To amplifier for Probe No. 3
DR321
DR
18μf
10K
100KΩ
2N498
Transistor "A"
Transistor "B"
Transistor "C"
R_{LC}
R_{LB}
R
95V
R_{LA}, R_{LB}, R_{LC} - P and B BS 23L 6PDT,
10KΩ, 7.6 ma Kick in Relays

Figure 12 — Amplitude comparator for discrete orientat angle method of polarization analysis.

and front end circuitry of this model is identical to that the analog model. In fact the inputs to the comparator the discrete orientation angle model is taken from the o put terminals of the receiver channels of the analog mo (see Figure 9). These inputs are essentially 60-cycle si waves whose magnitudes are proportional to the linea polarized components of the incident wave as measur by the three probes of the polarization resolver.

The three input voltages are detected and compar in the circuit shown schematically in Figure 12. Each the transistors controls current to the solenoid of one three six-pole-double-throw switching relays. Transist A conducts when the voltage from probe 1 is greater th that from probe 2, Transistor B conducts when the volta from probe 2 is greater than that from probe 3 and Tra sistor C conducts when the voltage from probe 3 greater than that from probe 1. When the transisto conduct, the corresponding relays, A, B, and C are act ated. Actuation of the relays occurs according to the quence shown in Table 1 below for the indicated rang of x. V_1, V_2, and V_3 are maximum when x is 0, 60, a 120 degrees respectively.

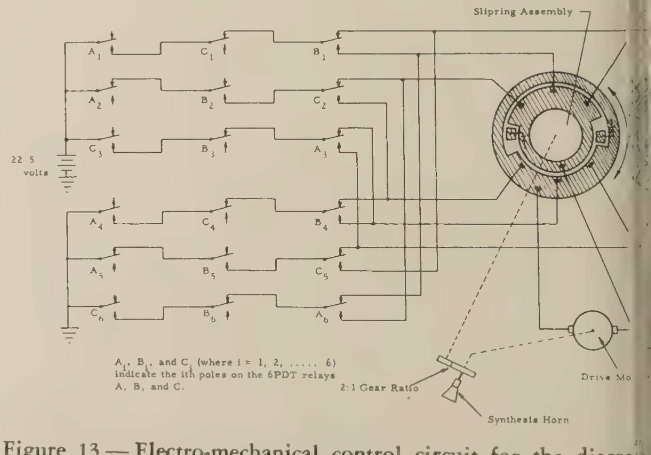
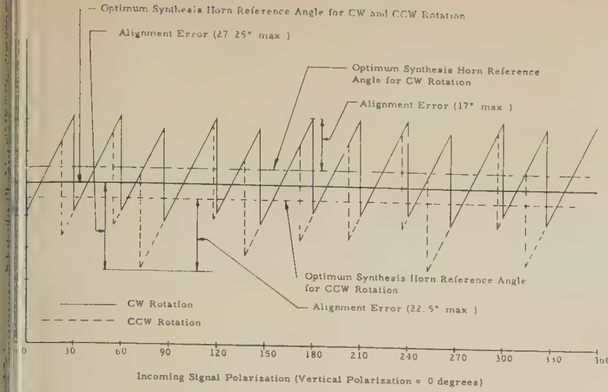


Figure 13 — Electro-mechanical control circuit for the discre orientation angle polarization analyzer.



ure 14 — Polarization alignment error of experimental model demonstrating the discrete orientation angle method of polarization analysis and synthesis. Incident wave linearly polarized.

TABLE I

x	Relay A Actuated when $V_1 > V_2$	Relay B Actuated when $V_2 > V_3$	Relay C Actuated when $V_3 > V_1$
— 30°	actuated	actuated	not actuated
— 60°	not actuated	actuated	not actuated
— 90°	not actuated	actuated	actuated
— 120°	not actuated	not actuated	actuated
— 150°	actuated	not actuated	actuated
— 180°	actuated	not actuated	not actuated
— 210°	actuated	actuated	not actuated

A switching circuit which uses the three six-pole-double- ow relays A, B, and C, to apply voltage to one of six ally spaced brush positions on the slotted slipring is wn in Figure 13. Voltage is applied to an adjacent ush position whenever the orientation angle of the in- lent wave changes by 30 degrees. The 22 1/2 volt bat- y then supplies voltage for the motor until the slipring embly indexes to this position. It is evident from ble I that a complete cycle of relay switching occurs 180-degree change in x. This again is a result of the mparison of probe voltage magnitudes only. A two to e gear ratio is therefore necessary between the synthesis rn and the slotted slipring assembly for proper correspondence of synthesis angle to incident polarization orien- ion angle x.

Both terminals of the reversible motor are connected rough the slipring assembly and switching network to e two terminals of the battery. This allows the motor turn in both directions. In fact the switching arrange- ent shown always results in the motor turning in the ortest direction when a voltage is applied to a new ush position.

The two diodes are used in conjunction with the slip- ngs so that a 90-degree change of incident signal polari- tion, causing a 180-degree change of polarization of the rushes of the slipring assembly can be detected by the rive motor. An otherwise possible "dead" spot is thus erted.

Experimental tests were conducted using the set up own in Figure 11. The same transmitting set-up as escribed in the testing of the analog model was used for is model also. The linearly polarized transmitting horn as rotated in polarization through 360 degrees and the rresponding position of the synthesis horn recorded. A lot of the error in alignment for 180 degrees of rotation shown in Figure 14. A hysteresis effect can be noted hen the transmitting horn is rotated in opposite directions which is due to the fact that the relays have some overlap in values of opening and closing voltage. Although the maximum magnitude of error from a center reference angle compares favorably with the theoretical value of 15 degrees if rotation is in only one direction, hysteresis effects result in a maximum error in alignment of over 27 degrees when rotation in both directions is considered. This error can be reduced to a value nearer the theoretical value if more sensitive or electronic relays are used.

In general, operation of the experimental model was considered satisfactory although the discrete method of alignment is not much simpler or less expensive than the analog method and compromises coupling to a greater degree. Both models were evaluated using CW type incident waves but analysis and synthesis of pulse type signals would be possible with some modification of circuitry.

IV. SUMMARY AND CONCLUSIONS

The foregoing has described some methods which may be employed to accomplish polarization analysis and synthesis. Preliminary experimental models have verified the feasibility of two of the methods. Since each system described has certain limitations, it is necessary to examine the particular intended use for polarization analysis before the choice of a specific method can be made. Included among systems which can benefit from polarization analysis and synthesis are those involving satellite or missile telemetry, interrogation, communication, tracking or jamming. Use of one of the described methods of polarization analysis in electronic systems can add overall effectiveness, sensitivity and range.

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DOPPLER METHOD
For ABSORBER TESTING

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I. Introduction

In order to specify the quality of an absorber, it is current practice to quote the "plane wave" reflection factor r for different angles of incidence and polarization of the incident electromagnetic wave. Good absorbing materials for short electromagnetic waves reflect only about one per cent of the incident energy. The accurate measurement of such low reflection factors poses a difficult problem. In a rigorous sense, this reflection cannot be determined experimentally at all, since, in order that the laws of geometrical optics apply, the absorber test sample should be an infinite plane wall, and transmitter and receiver antenna should both be at infinity to provide for a plane incident wave.

In practical tests to determine r, only one of the two conditions, infinite wall and plane wave, can be fulfilled to a high degree of approximation in different methods. In the "Arch" method,* Figure 1, transmitting antenna and receiving antenna are not at infinity but rather close to a large plane sample of absorbing material. Essentially, only a section of the absorber is illuminated, so that the absorber represents an infinite wall in the sense that the total radiation impinges on the absorbing material. Part of the incident radiation is reflected into the receiving antenna. By comparison with the amount reflected by a metallic plate under the same conditions, an approximate value for the "reflection factor" r is obtained. The approximation here is, that the incident radiation is not a plane wave, but varies in phase and amplitude across the illuminated region.

In another technique**, Figure 2, emphasis is placed on the condition that the test sample shall be illuminated by a plane wave. Consequently, the test sample must be relatively small, in the order of several wavelengths in linear dimensions, so that the phase and amplitude error of the incident wave originating from a distant transmitter is negligibly small. The receiving antenna placed at a distance which is approximately equal to larger than the distance between source and sample, aw from the test sample. It measures the total diffractic field of the test object in the far zone of the sampl Standard technique is to compare this response under th same geometrical conditions to the total diffraction fie of a metallic plate with equal transverse dimensions ar express the quality of the absorber sample by the rat of the two measured field strengths

$$x\ \text{db} = 20 \log \left| \frac{E\ \text{absorber}}{E\ \text{Metal}} \right| \qquad (1$$

One of the difficulties in a measurement using th technique is that in view of the necessarily small size the test object and its very low reflection factor, th signal picked up by the receiving antenna is relativel small compared to the total radiation emitted by th transmitter. Therefore, reflections from the illuminate

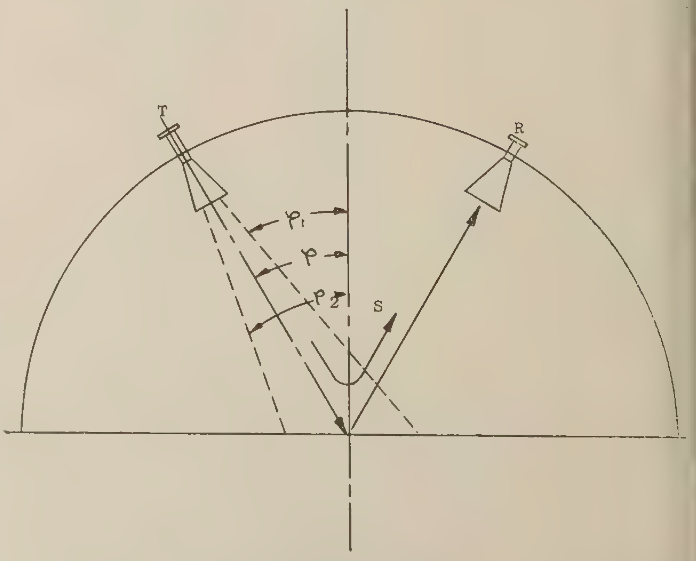

Figure 1—"Arch" method for measurement of reflection facto

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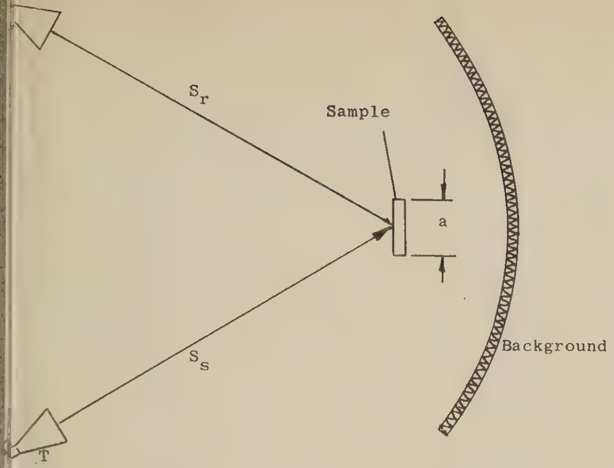
* C. G. Montgomery, Rad. Lab. Series Vol. 11, pages 612-616, McGraw-Hill 1947.

** E. Meyer, H. Severin, G. Umlauft, z.f. Physik 138 p.d. 65 (1958)



igure 2 — Measurement of reflection from small sample.

kground behind the sample, including the sample sup-
t, may produce a serious error in the measurements.
s holds particularly for the region directly behind the
orber sample in the geometrical shadow zone of the
ect. Independent of whether or not a cancellation of
total "background" signal (received signal without
ple) is carried out electronically, the reflection of this
ion must be much smaller than the reflection factor of
test sample to be measured. If this is not fulfilled, the
ct of the test sample to match a certain, in general un-
wn, background is measured, i.e. a "gray camouflage,"
er than the absolute reflection. In other words, if an
orber of one per cent power reflection (20 db dis-
nination compared to a metallic plate) is placed in
nt of a 20 db absorber wall used as background, it may
ear as a perfectly matched absorber.

n principle, the signal from the test sample and the
nal defined as "background" can be separated in time
ng a short pulse method *** or a separation in fre-
ency can be achieved by putting the test sample in
t motion.**** The frequency of the electromagnetic
nal reflected from the test sample is shifted due to the
ppler effect. Only this component is detected and thus
mpletely separated from the reflections from the sta-
nary background. In general, the application of ex-
mely short pulses requires fairly complex broadband
ctronic equipment, so that the Doppler technique des-
bed in this report appears more feasible.

The Doppler Set Up

If the test sample is moving with the velocity v towards
e stationary source, the frequency shift at the stationary
int of observation is

$$\triangle f = \frac{2v}{c} f_o \qquad (c = \text{velocity of light})$$

r operating frequencies f_o in the microwave range $\triangle f$
in the low audio range for technically possible speeds in
e order of five m/sec. In a practical system, the re-
cted signal, shifted by the amount $\triangle f$ in frequency, is
eived and mixed with a constant signal at the carrier frequency. The low frequency output, assuming a square law characteristic for the mixing crystal is

$$A_{f_o + \triangle f} \cdot B_{f_o} \cos (2\pi \triangle f t)$$

where $A_{f_o + \triangle f}$ is the amplitude of the frequency shifted signal and B_{f_o} is the amplitude of the carrier signal. The response is proportional to the amplitude of the wave reflected from the test sample.

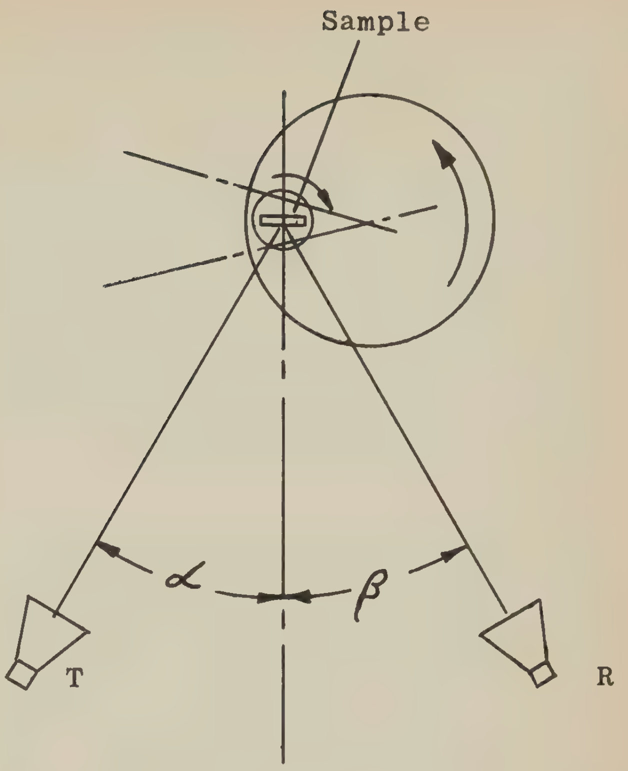


Figure 3 — Sample support on ground screen for Doppler technique.

The effect of the stationary background and the antenna cross coupling is now at most a weak contribution to the carrier signal, which even for a background only fair in quality can be neglected in view of the larger carrier signal which is externally fed into the mixing device directly from the source. In effect, the amplitude $A_{f_o + \triangle f}$ is essentially indepedent of the amount of reflection from anything behind the test sample, assuming multiple scattering to be negligibly small.

A serious problem, however, is posed by the sample support itself, which in general moves with the same velocity as the test sample, and thus its reflections contribute to the response. Under the restriction that only measurements with the electric vector perpendicular to the plane of incidence are to be conducted, this can be resolved by the use of a large metallic ground screen as sketched in Figure 3. In this type of arrangement, the linear motion is conveniently replaced by a circular motion on a large round metallic disk, which is rapidly rotating in a corresponding hole in a sufficiently large, electrically nearly infinitely large, metallic image plane. In order to keep the flat front of the test sample always facing one direction, an insert disk supporting the test sample is rotating in the counter-sense. The actual measurement is made in a short time interval when the test sample is moving through a narrow sector. During this time, the

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** C. C. N. Tang, Cruft Lab. Scientific Report 15 (1958) Harvard University.

** H. Scharfman and D. D. King, Proc. IRE 42, p. 854, May 1954.

motion can be considered to a high degree of approximation as linear.

The application of the ground screen technique is permissible, because of the symmetry of the absorber test samples. The question of the size of the test sample still has to be discussed, though. Whenever the reflection from samples of finite size are measured, the assumption is made, that the ratio of the total diffracted fields measured in the direction of geometrical reflection from the plane sample, $\left|\dfrac{E\ \text{absorber}}{E\ \text{metal}}\right|_{\text{Farfield}}$ is a constant, essentially independent of the size of the sample, and is equal to the geometric reflection factor for an infinite wall of the same material. This, of course, can only be true in an asymptotic sense. The measured ratio will approach the geometric reflection factor if the sample is made larger and larger. For the special case of plane circular metallic disks and normal incidence of the electromagnetic wave the geometric optical calculation of the back scattering cross section is a good approximation for radii larger than about half of a wavelength. It is to be expected, that the minimum size required must be larger, the smaller the geometrical reflection factor of the plane sample is, in order to give a meaningful measurement. Accurate data are not available, but one can estimate that for an absorber of one per cent power reflection the linear dimension should not be smaller than

$$a \sim 5\lambda \qquad (2)$$

where λ is the wavelength of the test signal and a the linear dimension of the flat sample.

Assuming Equation 2 as a lower limit on the sample size, the minimum distance S between the apex of the transmitting antenna and the test sample, so that the incident wave can be considered a plane wave, can be computed. In practice, the far zone condition requires

$$S \geq \frac{2D^2}{\lambda} \qquad (3)$$

where D is now the linear dimension of the aperture of the antenna, or the linear dimension of the test sample, whichever is larger. Under the assumption of a spherical wave originating at the apex of the horn antenna the phase error at the edges of the test sample is smaller than $\lambda/16$ which may be considered negligible. In order to give a defined meaning to the measured results, Eq
tions 2 and 3 have to be fulfilled simultaneously, so t
a minimum distance between source (or receiver) a
test sample of roughly $S \sim 50\lambda$ is obtained.

In order to test the reflection properties of absorbi
material, an equipment based on the Doppler princi
and incorporating the image plane technique has be
built. A photograph of the entire equipment is given
Figure 5.

The image plane, a 120° sector of a circle, is construct
of several large sections of plywood covered with alu
num and copper sheets. The overall length is 22 feet.
is mounted about one meter above the floor of the lar
laboratory room, so that driving gear for the large
tating disk and a belt drive for the counter rotati
smaller disk can be mounted under the table. T
diameter of the large disk is 62 inches, while the smal
disk has a diameter of one foot, allowing a sample size
at least five λ at the higher end of C-band and
shorter wavelengths. The center point of the test samp
describes a circle with a diameter of four feet around t
center point of the large disk. The gap between grou
screen and rotating disk is approximately 1/16 inch. T
entire rear end of the ground screen is surrounded
standard two inch absorbing material to make negligi
the contribution of laboratory walls to the carrier f
quency signal.

Transmitting and receiving antennas consist of two ide
tical "half horns." The distance between antennas a
the test sample fulfills the far zone requirement (Equ
tion 3). The antennas can be moved in angular directio
α, and β by about 55 degrees.

The electronic part is indicated schematically in Figu
4. The signal provided by a klystron is fed into a "
where it splits into the part radiated by the transmitti
antenna, and the part used as the "local oscillator" c
rier frequency f_0, which may be adjusted in intensity
a variable attenuator. The receiving antenna picks up t
reflected signal $A_{f_0} + \triangle_f$. This signal is fed together wi
the carrier signal to a crystal diode. The audio frequen
output is amplified and filtered out by means of a variab
band pass filter, to reduce the effect of klystron noise.
commutator switch actuated by the drive shaft of t
large rotating disk allows to short circuit the amplifi
output at all times, except when the test sample mov
through the desired sector. It was found, that a sect
width of about 5 - 10 degrees was very satisfying. T

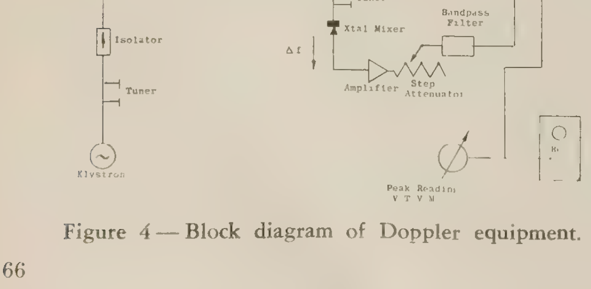


Figure 4 — Block diagram of Doppler equipment.

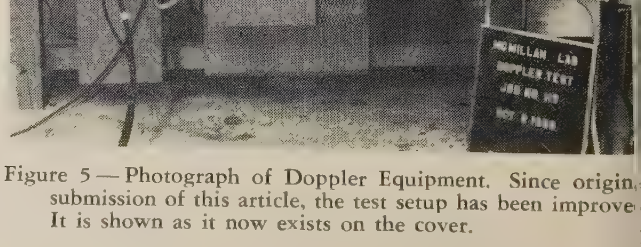
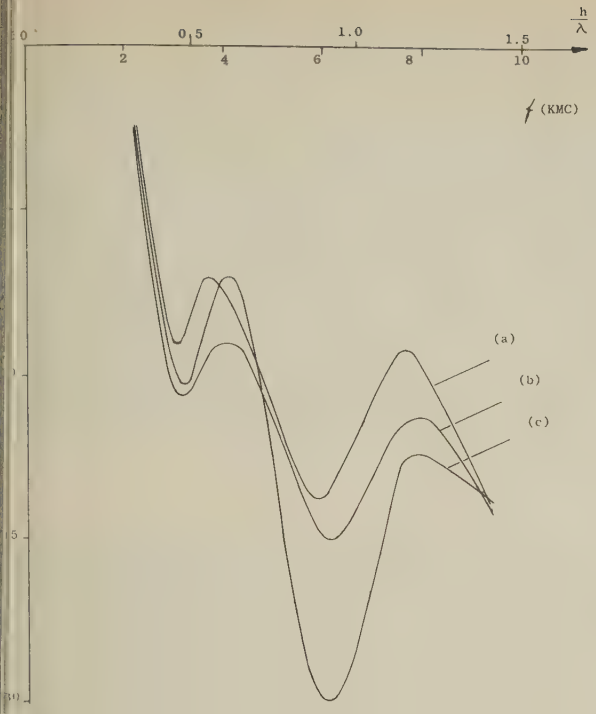


Figure 5 — Photograph of Doppler Equipment. Since origin
submission of this article, the test setup has been improve
It is shown as it now exists on the cover.



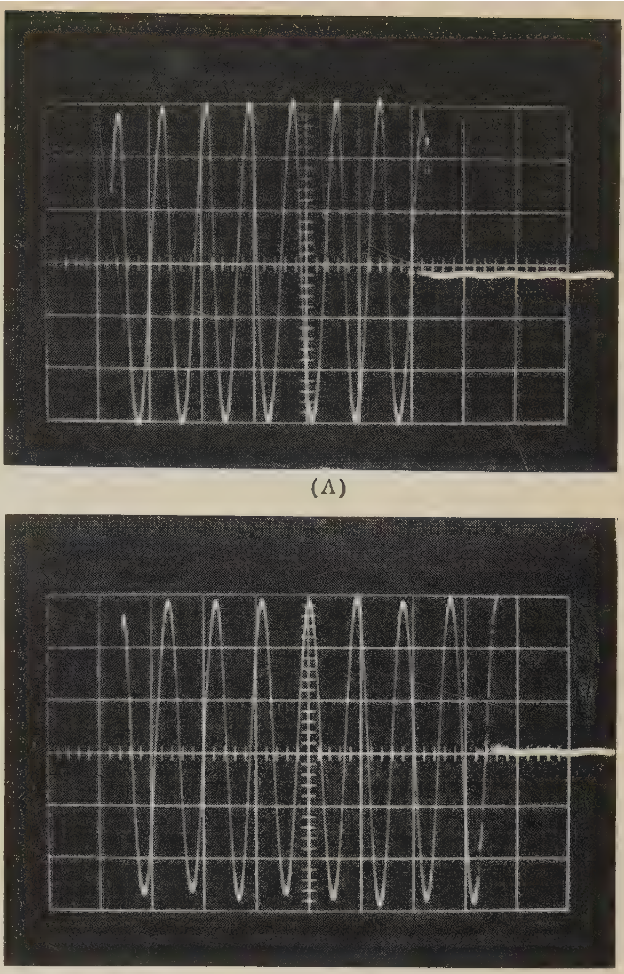
re 6 — Reflection from 3 standard 2″ absorber samples, (McMillan BL-2) in decibels below metallic reflection as a function of frequency. Upper axis scale shows ratio of cone height to wavelength. Angle of incidence 9°.

and position of this sector can be varied, however, by sting the commutator. When the sample is moving ough the pre-set sector, the amplifier outlet is led to a pe where it can be photographed or to an integrating k voltmeter. The reading on the scope is a linear asure for the amplitude reflected from the test sample. e linearity has been checked by measuring a set of flat allic disks of half circular shape, for which the total k-scattered signal is theoretically known.

The support of the absorber sample to be tested is ieved by a strong aluminum bracket in the shadow of metallic reference plate, screwed to the smaller rotating k. The metallic reference plate serves also as a backing te for the equally large absorber samples, which are at- hed by a small rubber band placed around the absorber l the metal plate. During the actual measurement, the orber is firmly pressed against the backing due to the nd produced. The speed of rotation can be continu- ly adjusted up to about 200 RPM corresponding to a gential velocity of 10 m/sec.

In testing the set-up, disturbances from two sources ve been investigated. The edges of the rotating disks, rticularly the smaller disk, move with about the same ocity as the absorber sample. Thus a response may be ained even without test sample, if the disks are not en- ly flat and protruding sectors move periodically up and wn. After carefully adjusting the disks to an accuracy about 1/10 inch, the Doppler signal received from the ating disks alone was more than 40 db below the re- nse from a metallic plate of dimensions 15 cm x 7.5 , the smallest size used, at three cm wave length. This eoretically allows to measure reflection factors in the ler of 1/100 per cent of the energy.

The second source of error consists of scattering from test sample towards the side edges of the ground screen and subsequent scattering into the receiver. Since this is a multiple scattering effect, the magnitude is extremely small. It has been found experimentally, that reflecting bodies can be almost arbitrarily placed along the edges of the image plane, as well as behind the test sample, without effecting the measured results on commercial absorbers at all.


(A)

(B)

Figure 7 — Photographs of Doppler response on Oscilloscope.
a) metallic reflector 8″ x 4″.
b) absorber sample of equal size.

III. ABSORBER TESTS

Using the Doppler test set-up, a series of reflection measurements have been made on commercial absorbers †. The frequency dependence of the geometric reflection factor has been determined for an angle of incidence of 9°. Results for three samples taken out of the production are plotted in figure 6. The plot of the power reflection factor shows the usual low-frequency cutoff, when the height of the lossy cones is roughly one half of the free space wavelength. At higher frequencies the reflection factor shows relative maxima alternating the relative minima, which is in accord with an approximate theory developed by Lenz*****. The slight differences in the reflectivity of the three samples are due to manufacturing tolerances in the coating of the foam matrix.

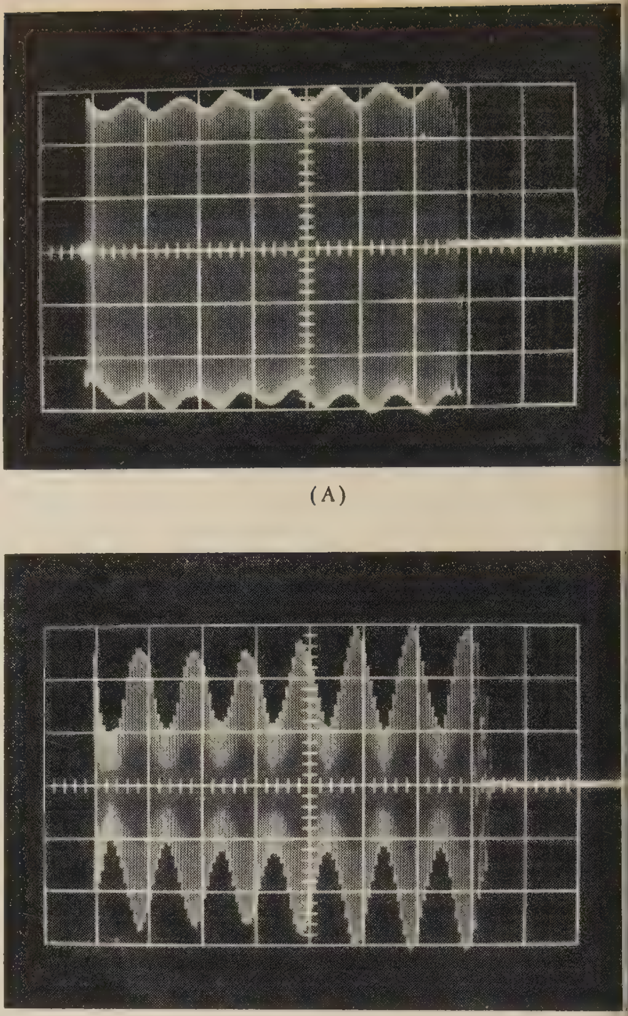
---

† McMillan Type BL-2. This absorbing material consists of a matrix of hollow cones in a 2″ thick styrofoam block. The walls of the cones are covered with a semi-conducting material.

***** K. L. Lenz, Z. angew Physik, Vol. 10, p. 17-25 (1958).

A typical Doppler response obtained from the reflection of a metallic plate is shown in Figure 7a. The response from the metallic plate with the absorber in front is seen in Figure 7b. In the experiment, the reduction in reflectivity is measured on a calibrated attenuator which is successively adjusted to give equal response amplitude on the oscilloscope for the reflection from the metallic reference plate and the test sample. In this case the absorber reduced the reflected signal by about 20 db (one per cent energy reflection). Small ripples are seen on the signal trace, which are believed due to the changing background contribution to the carrier signal. By taking the average value of the peak amplitude this error may, of course, be eliminated.

It is interesting to compare the Doppler set up with the standard measurement technique, in which the background reflection is not separated. This is easily achieved in this set-up by modulating the transmitter as usual with pulses, eliminating the local oscillator connection and taking out the Doppler frequency filter. The response obtained from the metallic plate and from the plate covered with an absorber of about 20 db discrimination are shown in Figures 8a and 8b. Both pictures show the interference of background signal and the signal reflected from the test sample. In the case of the metallic reflector, the background interference is relatively weak, producing only small ripples. If the absorber sample is put into place, the background signal strength is comparable to the actual signal and produces strong maxima and minima, while the sample is moving through the measurement sector. These extrema are particularly marked at the beginning of the signal trace, the point at which the test sample is closest to the background wall. Here the interference between both reflected waves may produce almost cancellation, and the 20 db absorber would appear as nearly perfect, if measured at this point. In a test procedure without using the Doppler principle, the effect of the background interference on the results must be reduced by varying the test sample position by at least a quarter wavelength.



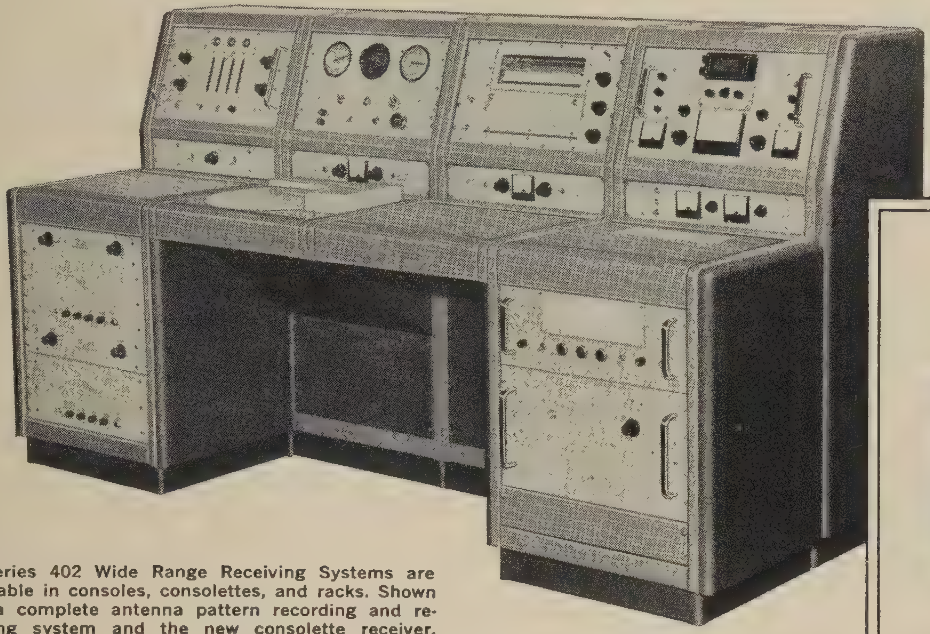
(A)

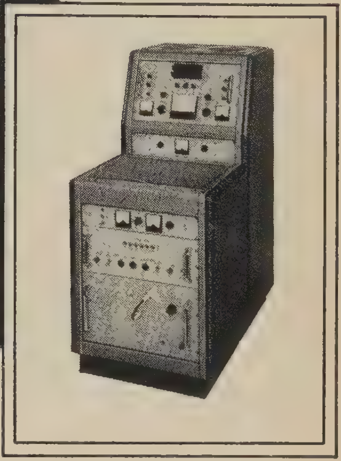
(B)

Figure 8 — Oscillographic response with pulse modulation stead of Doppler modulation.
a) metallic reflector 8″ x 4″.
b) absorber sample of equal size.

MAJORS and MINORS

. . . A Message to the Antenna Designer





● Series 402 Wide Range Receiving Systems are available in consoles, consolettes, and racks. Shown are a complete antenna pattern recording and receiving system and the new consolette receiver.

crowded spectrum plus high power radar and com- unication systems critically compound the problems of e antenna design engineer.

ore than ever, the complete pattern including **all** the ajor and minor lobes of every radiating element must e graphed for sound engineering evaluation.

-A Receiver Gets the Whole Signal

cientific-Atlanta Series 402 Wide Range Receiving ystems are specifically designed for antenna pattern easurements. Unique in design, these receivers combine aximum sensitivity and linearity from 30 mc to above 00 kmc. They are also useful as multipurpose laboratory nstruments for microwave testing, monitoring, and meas- ring applications.

Only from S-A, 1 db Linearity over Full 60 db Dynamic Range

recent development, S-A's P-4 modification adds 20 db o the normal 40 db dynamic range. The modification akes advantage of the gain vs AGC voltage character- stics of the Series 402. Existing receivers can be modified t the factory.

New Modification Z Broadens Use

Modification Z adds a precision IF attenuator and VTVM o the Series 402. Now RF and microwave signal level, gain, and isolation measurements can be made with fewer omponents and instruments. *For instance,* an X band 30 db attenuator can be calibrated to within ±0.5 db with a 1 mw signal source, a flap attenuator, a mixer, and an S-A Series 402Z Receiver. Antenna gain can be measured by direct comparison with a standard gain antenna. Signal levels can be compared against a reference standard.

Other Features

One coaxial cable from antenna to receiver eliminates costly lossy waveguides and rotary joints. Antenna can be located up to 75 feet away with negligible loss in sensitivity ☆ One receiving system covers 30 mc to above 100 kmc without plug-ins ☆ Reception of cw signals from simple sources eliminates need for precise modulation ☆ High sensitivity means low source power and long ranges ☆ High selectivity reduces interference and cross talk between adjacent test ranges ☆ Positive AFC action over full dynamic range provides pattern recording in deep nulls.

PRICES

Series 402, 2 to above 100 kmc	$7500
Series 402A, 2 to above 100 kmc with AGC	8000
Series 402B, 30 mc to above 100 kmc	8500
Series 402C, 30 mc to above 100 kmc with AGC . .	9000
Modification P-4	500
Modification Z	1000

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3

Circle Reader Service Card 32

(*Continued from page 36*)

TOMIYASU JOINS GENERAL ELECTRIC

Dr. Kiyo Tomiyasu has joined the General Engineering Laboratory, General Electric Co., Schenectady, N.Y. as Microwave Engineer, RF and Communication Engineering.

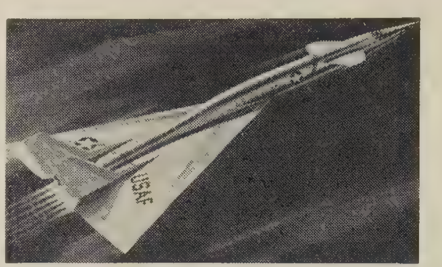
A native of Las Vegas, Nev., Dr. Tomiyasu received a BSEE degree from California Institute of Technology in 1940 and an MSEE degree from Columbia University in 1941. He also studied at Stanford University on a Low Scholarship and at Harvard University as a Gordon McKay Scholar. He received his PhD in Communication Engineering from Harvard in 1948, and served one year there as an instructor in the Lyman Laboratory.

From 1949 to 1955, he was with the Sperry Gyroscope Co., in charge of microwave research engineering. He then joined the General Electric Co. as consulting engineer in the Microwave Laboratory at Palo Alto, Cal. where he worked on projects related to microwave frequency memory, high power duplexers, filters, harmonic measurements in waveguide, electron ballistics, and numerous other problems. Since 1959, he has been consulting engineer to the High Power Klystron Sub-Section. He was editor of the IRE Transactions on Microwave Theory and Techniques for two years (1957-58) and is presently a member of the IRE Editorial Board.

Dr. Tomiyasu holds 12 patents and has authored 16 published papers. A senior member of the IRE, he is presently Chairman of the Administrative Committee of the IRE Professional Group on Microwave Theory and Techniques. He is also a member of the American Physical Society and of Sigma Xi.

—mwj—

B-70 & BU WEP ANTENNA CONTRACTS AWARDED TO TRANSCO



Two new contracts covering work on advanced design microwave antennas have been awarded to Transco Products, Inc., of Los Angeles, Cal. according to Marshall Sawyer, Sr., president.

A contract from the U.S. Navy Bureau of Naval Weapons covers original research and development on high altitude, high temperature, flush mounted antennas for L-Band, UHF communications, and Marker Receivers.

The other contract, awarded to Transco by North American, covers the design and development of communications, navigation and identification antennas for tl B-70. These consist of three L-Band IF] TACAN units, two UHF communicatior antennas and one for Marker Receive Transco will do the antenna design, as we as conduct all environmental testing their extensive West Los Angeles facilit

—mwj—

QUALITY CONTROL DIRECTOR APPOINTED BY MELPAR, INC.

Robert C. Murrell has been appointe Director, Quality Control, at Melpar, Inc Falls Church, Va., it was announced b Edward M. Bostick, Vice President an General Manager.

Formerly Quality Control Manager c the Engineering Division, Mr. Murre now has Quality Control responsibilit for both the Engineering and Productio Divisions. Mr. Murrell started with Me par in January 1953 as a Test Enginee Later as Quality Control Manager he wa responsible for setting up test program developing quality control tests and supe vising the general quality control prograr for the Engineering Division. This ir volved electronic reconnaisance system radar beacons and other electronic equip ment.

In 1949 he joined Midwest Engineerin Development Company, Kansas City, Mi souri, as a test engineer and from 195 to 1953 he was attached to the U.S. Arm Signal Corps Engineering Laboratories a Fort Monmouth, New Jersey, on ne equipment introductory teams. Originall from Kansas City, Kansas, Mr. Murrell re ceived his BSEE in 1950 from the Uni versity of Kansas and attended Kansa City Junior College. Honor society mem berships include Tau Beta Pi and Sigm Tau.

—mwj—

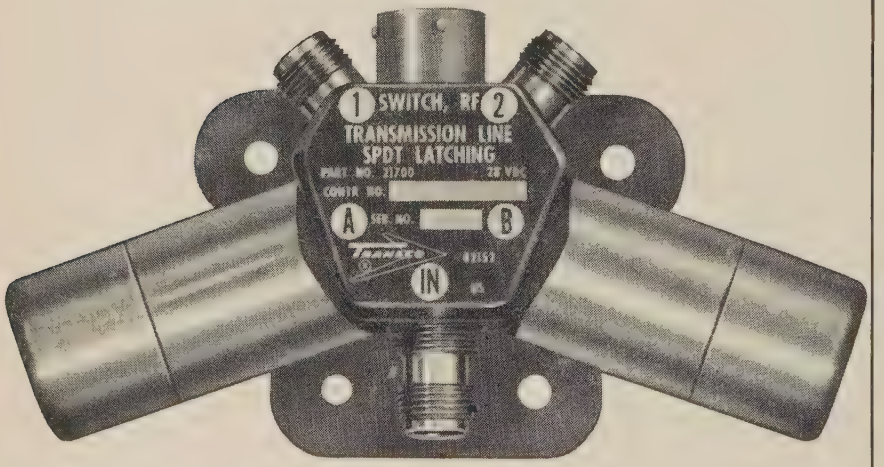
E. J. WARNER MADE SALES MANAGER OF DOUGLAS MICROWAVE

Edward J. Warner, President and Man ager, Application Engineering, Spectr Electronics Corp., has been appointe Sales Manager of the Douglas Microwav Co., Inc., Mount Vernon, N.Y., manufac turers of microwave test equipment an components.

Mr. Warner will continue in his posi

(*Continued on page 72*)

NO
HOLDING
POWER
NEEDED



NEW TRANSCO COAXIAL LATCHING SWITCH

No holding power needed with this new Transco switch. Solenoids stay cool, ending heat worries. Compact unit operates to 11 KMC and meets military specifications. Typical specifications at 7 KMC: IMPEDANCE 50 ohms; VSWR 1.3; INSERTION LOSS 0.3 db; CROSSTALK 40 db; WEIGHT 8.7 oz. Please write Transco Products, Incorporated, 12210 Nebraska Avenue, Los Angeles 25, California for complete information.

TRANSCO

COAXIAL SWITCHES • WAVEGUIDE SWITCHES • ANTENNAS • MICROWAVE COMPONENTS • VALVES • ACTUATORS

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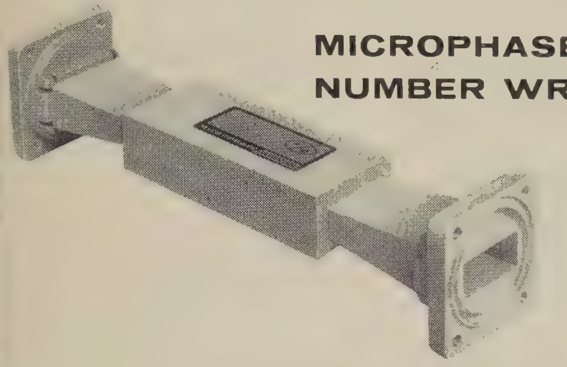
MC Waveguide Filters

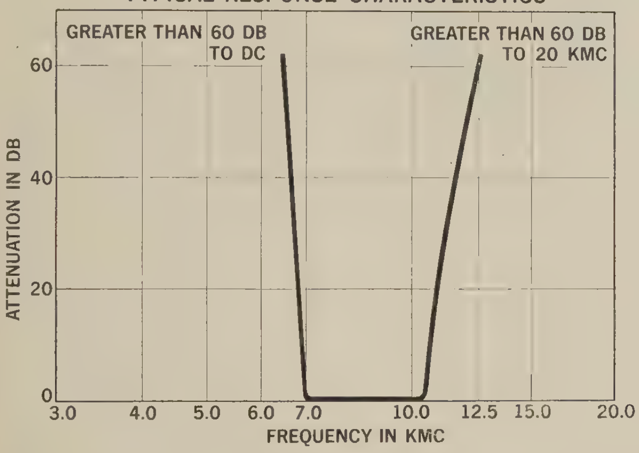
μ/φ

EDIUM-HIGH POWER VAVEGUIDE BAND-PASS FILTER OR RG-51/U WAVEGUIDE SYSTEMS

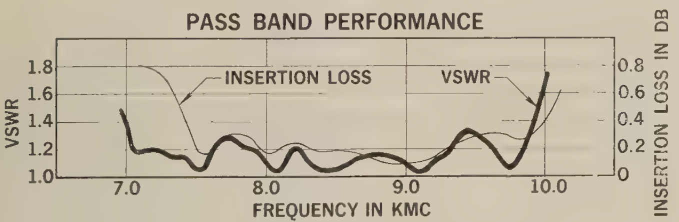
MICROPHASE PART NUMBER WR310LSX1



TYPICAL RESPONSE CHARACTERISTICS



PASS BAND PERFORMANCE

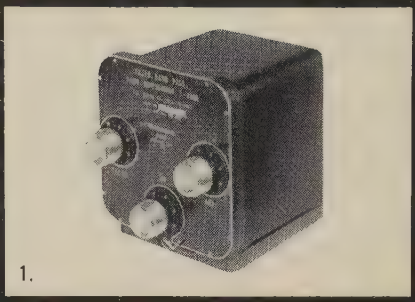


The usable bandwidth of this filter extends over the range of the RG-51/U waveguide. Optimum insertion loss and VSWR is obtained from 7.5 kmc. to 9.8 kmc. This improved filter design provides 60 db. rejection up to 20 kmc. in a physically short overall length. The unit is pressurizable and at atmospheric pressure estimated power capacity is 100 KW peak.

Physical characteristics:

Flanges: UG-52A/U, choke both ends
Length: 8″
Weight: 22 oz.

Units with comparable or better performances in other waveguide bands are also available on short time deliveries.



1.

2.

1. IFF/TACAN DIPLEXER

Military Nomenclature:	Filter, Band Pass, Band Suppression F-339/A with Plate, Mounting MT-1904A
Federal Stock Number:	5915-670-0698
Microphase Part Number:	BER-2912C

This filter is used for coupling IFF and TACAN systems. The unit is fully qualified and meets the requirements of Specification MIL-F-25880A (USAF) in its entirety.

The BER-2921C filter is available from stock in small quantities and may be supplied for production requirements on accelerated schedules.

A unit with a different form factor and with connectors on opposite sides is also available from MICROPHASE. This filter, MICROPHASE part number IFT4L, is also engineered to meet applicable military specifications.

2. UHF/TACAN DIPLEXER

Basic Microphase Part Number: CB-2245 (B, C, D, and E)

This diplexer enables the simultaneous operation of communication and TACAN equipments from one broadband antenna. The insertion loss of the two operating channels, 225-400 and 950-1250 mc., is less than 0.4 and 0.6 db. respectively. This unit has excellent VSWR characteristics and, depending on the particular model, has 60 to 90 db. isolation between the channels. The diplexer may be provided with a variety of RF connectors and with special cabling for particular installations, as well as different mounting provisions.

MICROPHASE CORPORATION

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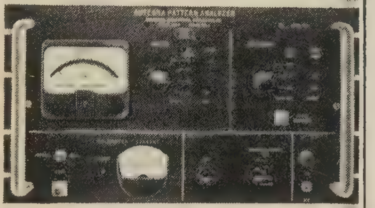
ANTENNA PATTERN ANALYZER MODEL BA-7

Measure 45 db (r. f.) in one step using a maximum of 1 microwatt r. f. power*

*100% square wave modulated at 1000 cps ± .1 cps. Observation time approximately 45 seconds for 45 db; only .2 seconds for 30 db.

Bandwidth variable from 2 to 15 cps with constant gain



MODEL BA-7

The BA-7 is the heart of a video detector system designed primarily for r. f. crystals. For greater versatility, a d. c. biasing circuit is included to permit use of conventional barretters, requiring a d. c. bias between 0 and 10 ma. The unit can be used to measure very high power ratios such as occur in making antenna pattern measurements, to determine the rejection coefficients of r. f. filters, and to calibrate attenuators. It has a wide dynamic linear range, a low noise level, and a wide r. f. frequency range where video crystal mounts are available.

For complete specifications, write for Bulletin No. 141.
Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog, specifying frequency range of interest.

WE CO

Weinschel Engineering
KENSINGTON, MARYLAND

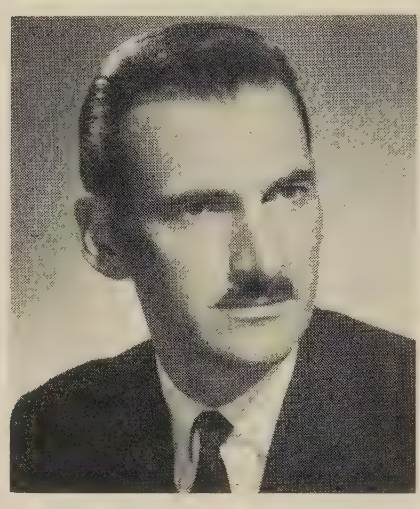
Circle Reader Service Card 35

(*Continued from page 70*)

tion with Spectra, a division of Douglas Microwave. The appointment was announced by Douglas' General Manager, Herbert M. Hendlin.

— *m w j* —

VARIAN NAMES DIRECTOR OF EUROPEAN PLANNING



Emmanuel P. Courtillot has been named to the newly created position of Director of European Planning for Varian Associates, Palo Alto, Cal., according to H. Myrl Stearns, president of the electronics firm.

A native of France, Courtillot is known throughout the U.S. electronics industry through his connection with various NATO projects and from his extensive work in this country on technical liaison with various American firms. He resigned as Manager of the Electronic Tube Division of Compagnie Francaise Thomson Houston (C. F. T. H.), the French electrical equipment and electronics firm, to accept the new Varian post.

In his new position Courtillot will be responsible for developing plans for Varian's expansion of sales and manufacturing in Europe. He will have his office at Zug, Switzerland, headquarters of Varian's European subsidiary, Varian A. G. Courtillot will report directly to Ralph Kane, Vice President, International Operations.

He is a past president of the Technical Committee of the French Association of Professional Radio Equipment Manufacturers and is a member of several French scientific societies as well as a Senior Member of the American Institute of Radio Engineers and a member of the Armed Forces Communications and Electronics Association.

Courtillot received his degree in physics from Ecole Superieure de Physique et de Chimie de Paris. He also holds a bachelor of law degree from the Sorbonne.

— *m w j* —

NEW COMPANY TO PRODUCE SPECIAL WAVEGUIDE MICROWAV COMPONENTS

MCS Corp., a new plant which wi build special microwave components fc prime contractors, microwave laboratorie and microwave system builders, is now i operation in Temple City, Cal., accordin to Louis Della Penna, president.

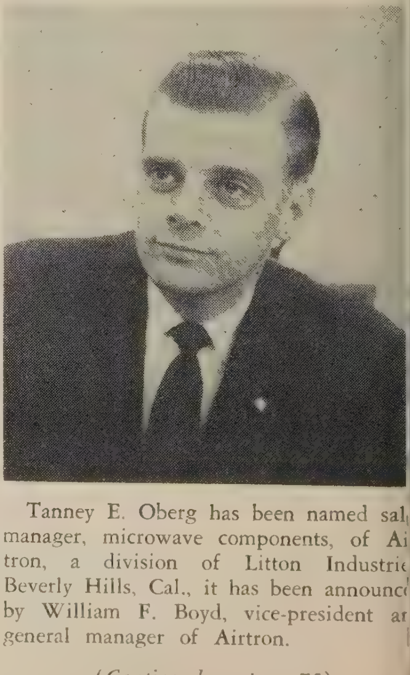
Mr. Della Penna, a pioneer in the manu facture of microwave equipment, has bee active in the field for the past 20 year Prior to starting MCS, he was with De Mornay-Bonardi, Pasadena, since 1954 a general manager of the company. Befor that he was production manager for th Budd-Stanley Co., Inc., Long Island Cit N.Y., and previously was works manage for DeMornay-Budd, New York City, fo 10 years.

A major purpose of the company, a cording to Della Penna, is to provide fully qualified source which can deliv quickly. "The West Coast especially nee such a source," Della Penna stated. " great deal of time and money can b saved by a manufacturer geared e pressly to handle special waveguide con ponents. Negotiating time is cut, an false starts or blind alleys eliminated. company providing dependable deliveri will fill an important need in the indu try."

MCS will produce to customer prints o customer requirements — any componen in the range from S band up to th millimeter wave region. The firm does i own precision machining, brazing, platin assembly of complex units, final testin and calibration. Representatives have bee appointed throughout the United States.

— *m w j* —

OBERG NAMED SALES MANAGER AT AIRTRON



Tanney E. Oberg has been named sal manager, microwave components, of Ai tron, a division of Litton Industri Beverly Hills, Cal., it has been announc by William F. Boyd, vice-president a general manager of Airtron.

(*Continued on page 75*)

w from Polarad

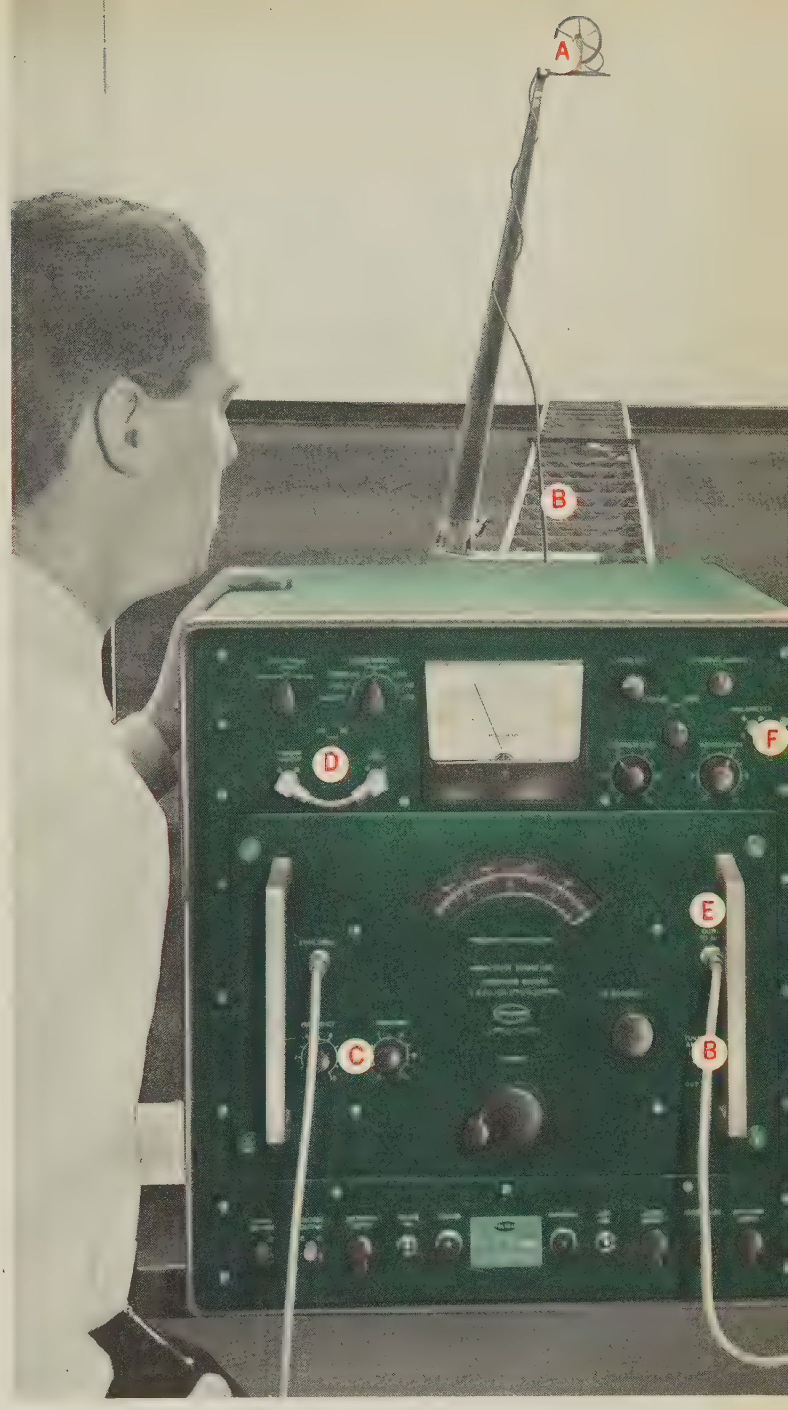
NTENNA ATTERN ICROWAVE ECEIVER

TRA-BROADBAND COVERAGE

2,000 to 75,000 mc in a single unit

- Ⓐ **External Mixer.** May be located at or near antenna, any distance up to 75 feet from receiver.
- Ⓑ **Flexible cable connects** mixer to receiver. Eliminates cumbersome rigid waveguide.
- Ⓒ **Internal electronic 1000 cps sweep** allows direct operation into any standard make AC antenna pattern recorder.
- Ⓓ **CW, AM, FM and pulse reception.**
- Ⓔ **Sensitivity.**
  - 2 kmc to 10 kmc....—85 dbm.
  - 10 kmc to 35 kmc....—80 dmb.
  - 35 kmc to 75 kmc....—70 dbm.
- Ⓕ **Linearity** maintained over 40 db dynamic range.

Model RW-T is another example of the versatility e well known Polarad Model R Microwave Reers. The RW-T is excellent to measure antenna pattern, minor lobes, front-to-back ratio, SWR bandwidth.



Model RW-T Microwave receiver being used to make antenna pattern measurements on Polarad range.

E LIFETIME SERVICE
ON ALL POLARAD
INSTRUMENTS

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

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Please send me information and specifications on:

☐ Model RW-T Antenna Pattern Receiver
☐ Model KSS Microwave Power Source (see reverse side of page)

My application is____________________

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New from Polarad

COMPACT MICROWAVE POWER SOURCE

1,050 to 11,000 mc 4 PLUG-IN UNIT

Model KSS Power Source being used to make antenna pattern measurements on Polarad Antenna Range. Can also be used for minor lobes, front to back ratio, SWR and gain measurements.

The new Polarad Model KSS features an advanced modulator design that provides CW, FM and internal square wave (10 to 10,000 pps). External pulse capabilities permit rise times to 0.15 μsec. The unit has an adjustable attenuator and low incidental AM and FM at relatively high power.

Ⓐ Basic unit (HU-4) includes modulator and power su into which is plugged any one of four R-F tuning Ⓑ that cover the frequency range 1,050 to 11,00 Tuning units are equipped with UNI-DIAL control Ⓒ automatically tunes klystron cavity with reflector volt

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43-20 34th St., Long Island City 1, N. Y.

POLARAD

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

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INSTRUMENTS

POLAR
ELECTRONI
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(*Continued from page 72*)

his new position, Oberg is responsi- for national sales of Airtron micro- components, including circulators, tors, mixer-duplexers and ferrite ches.

berg, who fills a new position with company, has been eastern sales super- r of the microwave division of Kear- Co. A BSEE graduate of Syracuse versity, Oberg has spent 10 years in tric and electronic engineering and s work. He is a senior member of the itute of Radio Engineers.

)berg will make his headquarters at tron's offices in Morris Plains, N.J. Litton division, which makes micro- ve components and is occupied with re- rch, design and development in micro- ve components, has facilities in Los geles, Calif., and Linden, N.J.

— mwj —

NIVERSITY STAFF MEETS WITH AIR FORCE, PIC BOARD

eneral Bernard Schreiver's aide, Colo- De Gennero, Dean Weston S. Evans the University of Maine and his en- ering professors met recently with tland Industries Corp., Portland, Me., ard of Advisors — Mr. J. R. Poppele, . John Teeter, Sir Robert Watson Watts and Ira Kamen, president of PIC, to up a program which will bring forth as to help National Defense and pro- te Air Research and Development Com- nd contracts for Maine.

Dr. John Teeter, who directs the Damon nyon Research Fund, offered a contract University of Maine for specific nu- ear research studies.

One of the important goals of the eeting was to develop ARDC research ntracts and arrange a future meeting ith the ARDC council to present the st ideas in Maine for funding, as re- arch contracts.

— mwj —

IL-E-CON 1961 REQUESTS PAPERS

The 5th National Convention on Mili- ry Electronics (MIL-E-CON 1961) will e held at the Shoreham Hotel, Wash- ngton, D.C., on June 26, 27, and 28, 961, under the sponsorship of the Pro- essional Group on Military Electronics f The Institute of Radio Engineers. Ma- or General Francis L. Ankenbrandt, JSAF (Ret.), member of the technical taff of Defense Electronic Products, CA, Camden, New Jersey, is Conven- ion President.

Papers presenting original work in nilitary electronics are invited for this neeting. Suggested topics include, but re not limited to the following: Cur- ent Problems of Space Technology, pace Electronics, Ranging and Tracking, lectronic Propulsion, Data Handling ystems, Guidance and Control, Inertial ystems, Reconnaissance Systems, Com- nunication Systems, Operational Analy- is, and Reliability.

The technical program will include both classified (limited to Confidential) and unclassified sessions, with the Air Research and Development Command sponsoring the classified sessions. An unclassified and bound *Proceedings* of the convention will be available at the meeting.

Prospective authors are requested to furnish the following information, *not later than February 1, 1961:* three copies of a 750-word unclassified abstract of the proposed paper, plus the name and position of the author and the name and address of his company or organization; and three copies of a biographical sketch of the author(s), including education, experience, memberships in professional societies, honors, and publications.

Each author must obtain the appropriate military and company clearances for his abstract. Send abstracts to: Mr. Harry Davis, SAFRD, The Pentagon, Washington 25, D.C.

— mwj —

FXR NAMES SALES HEAD FOR CUSTOM MICROWAVE COMPONENTS

Robert Pizzutiello, who has had extensive experience on radar and countermeasures systems, has been promoted to the new post of head of sales for custom microwave components and systems at FXR, Inc., Woodside, N.Y., manufacturer of microwave and associated equipment, William Marshall, vice president for sales, announced.

Mr. Pizzutiello will be responsible for contracting sales of radar, countermeasures, missile systems and subsystems, as well as custom-designed microwave components and assemblies.

Mr. Pizzutiello, a resident of Plainview, N.Y., received his electrical engineering degree from the City College of New York. He is a member of the Institute of Radio Engineers. Before joining FXR, he was with Sperry Gyroscope Co. and W. L. Maxson Corp.

— mwj —

WEINSCHEL ENGINEERING OPENS CALIFORNIA OFFICE

Due to the growth of the electronics industry in California and the subsequent greater demand for Weinschel instruments in that area, Weinschel Engineering, Kensington, Md., has opened a Field Engineering office in Santa Monica, Cal. This office will serve the missile, aircraft and electronic industries in the Los Angeles and San Diego areas.

Weinschel Engineering, which specializes in precision microwave calibration equipment, will break ground in early 1961 for a 50,000 square foot laboratory in Gaithersburg, Md., near the new National Bureau of Standards site.

— mwj —

SPERRY APPOINTS M. D. LOCKWOOD VICE PRESIDENT

Appointment of Myron D. Lockwood as company vice president was announced today by Carl A. Frische, president of Sperry Gyroscope Company, Great Neck, N.Y. Mr. Lockwood, who joined Sperry as a project engineer in 1945, has been manager of the company's Surface Armament Division since 1957.

At the same time, the electronics company advanced Thomas W. Melia, formerly assistant manager, to the position of division manager. He will report to Mr. Lockwood for operation of this key Sperry organization, a producer of military equipment such as super radars for missile guidance, detection and tracking, inertial navigation and fire control systems.

Mr. Lockwood was graduated from Virginia Polytechnic Institute in 1934 with a B.S.E.E. degree. He is a member of the American Institute of Electrical Engineering and the Institute of Radio Engineers, also Tau Beta Pi, Omicron Delta Kappa and Phi Kappa Phi fraternities.

During World War II he served with the U.S. Army, achieving the rank of lieutenant colonel. Among several key posts, he held that of technical advisor at the Electronics Training Center, Massachusetts Institute of Technology.

— mwj —

SPECIAL TUBE OPERATIONS BECOMES MICROWAVE DEVICE OPERATIONS

Sylvania Electronic Tubes, a division of Sylvania Electric Products Inc., New York, N.Y., has changed the name of its Special Tube Operations to Microwave Device Operations, it has been announced by W. Herbert Lamb, Vice President in charge of the division's cathode ray tube and microwave tube activities. Sylvania is a subsidiary of General Telephone & Electronics Corporation.

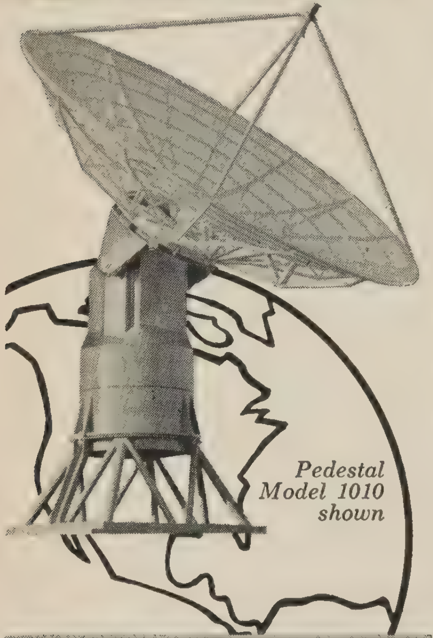
Increased emphasis on the development and manufacture of advanced microwave devices, including traveling-wave tubes, klystrons, magnetrons, backward wave oscillators, and ferrite devices, warrants an operational title which reflects this emphasis, Mr. Lamb said.

With headquarters at Mountain View and additional manufacturing facilities at Williamsport, Pa., Microwave Device Operations will continue to supply trigger tubes, counter tubes, vacuum measuring devices, and other non-microwave components to commercial, military and industrial markets, Mr. Lamb added.

— mwj —

(*Continued on page 76*)

ANTENNAS
by
Ainslie
CORPORATION



NOW — available from Ainslie Corporation, a new remote control positioning pedestal capable of handling our antennas up to 18 feet in diameter in frequencies from 100 to 10,000 mc. Modifications available for a variety of tracking applications. Whatever your antenna or reflector requirements may be, contact us at our new facilities.

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531 Pond Street
South Braintree 85, Massachusetts

Circle Reader Service Card 38

(Continued from page 75)

SYLVANIA WILL WORK ON ADVENT PROGRAM

Receipt of a $2.4 million contract for development, fabrication and installation of two 60-foot ground antenna systems for the U.S. Army Signal Corps' portion of the ADVENT satellite communications program was announced by Sylvania Electric Products Inc., New York, N.Y.

Richard M. Osgood, General Manager of Sylvania's Waltham Laboratories, said the award was made by the U.S. Army Signal Research & Development Laboratory, Fort Monmouth, N.J.

Project ADVENT, which is under the overall direction of the Advanced Research Projects Agency, embraces research leading to a world-wide communications network that will operate through utilization of "stationary" satellites. By orbiting some 22,000 miles above the equator in the same direction and at the same speed as the earth's rotation, each of the "stationary" satellites would appear to hover over a single ground point.

Mr. Osgood said work on the project will be carried on at the Waltham Laboratories with Kenneth W. Rau serving as project engineer. Mr. Rau previously was a member of the research staff of the Laboratories' Antenna & Microwave Laboratory.

—*mwj*—

DON-LAN EXPANDS

In a major expansion into manufacture of complete ultra-miniature high-efficiency radar antenna systems, Don-Lan Electronics Inc. has acquired an additional 17,500 square feet in a building in Santa Monica, Cal.

The expansion, according to general manager Harold W. Arlidge, has grown naturally from the firm's established position in making all of the various components used in antenna systems, including co-axial switches, attenuators, and radar antennas.

Engineering, sales offices and expanded manufacturing facilities will be located in the new building, which is adjacent to the firm's present quarters in Santa Monica. In addition to the additional facilities to be located in the building, the firm has acquired a site for an antenna pattern range, Arlidge said.

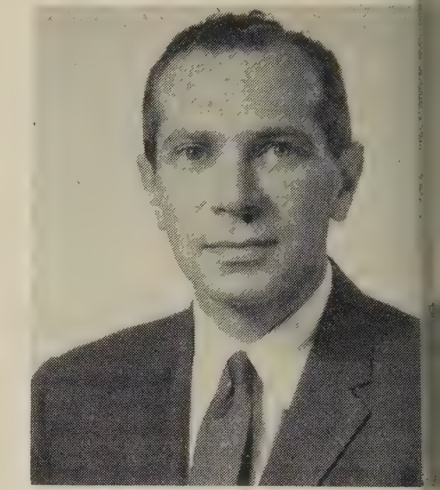
The expansion follows a broad plan of development into complete antenna systems, according to chief engineer Donald Lanctot, who founded the firm three years ago. Don-Lan now makes all of the parts used in antenna systems, but markets them separately as components. Lanctot said.

Now a subsidiary of Regan Industries, Inc., of Burlingame, Cal., Don-Lan was purchased through a stock transfer in July, 1958.

Products of the firm are aboard the Talos, Tartan, Atlas, Falcon, Sidewind and Pioneer V, and are engineered i many others.

—*mwj*—

RUBENSON HEADS NEW SYSTEM DIVISION



Joseph G. Rubenson, formerly techni manager of the multi-million dollar AI GLR-4 system program at the Mounta View operations of Sylvania Electro Systems Division has joined Watki Johnson Co., Palo Alto, Cal., as head the new Systems Division. He will port to Dr. H. Richard Johnson, executi vice-president of Watkins-Johnson.

From 1951 until joining Sylvania mid-1958, Rubenson was with the A borne Instruments Laboratory, Mineo N.Y., as section head responsible for pr grams in active countermeasures and i dustrial electronics. Earlier in his care Rubenson did development work on m crowave components and related test equi ment at the Polytechnic Research and D velopment Corp., Brooklyn, and served part-time instructor in electronics at Pol technic Institute of Brooklyn.

A native of Newburgh, N.Y., he has B.S. in Physics from City College of Ne York and a Master's in Electrical Eng neering from Polytechnic Institute Brooklyn. Rubenson is a senior memb of the Institute of Radio Engineers and member of Phi Beta Kappa and Sigma X

—*mwj*—

CONTRACT AWARDED TO WEINSCHEL ENGINEERING

The Dayton Air Force Depot has a nounced the award of a $39,550.00 co tract to Weinschel Engineering, Kensin ton, Md. Under this contract, Weinsch Engineering will supply model PB-1 Pr cision R.F. Power Bridges to be used i conjunction with an Air Force program t set up secondary standards laboratorie Model PB-1 was developed by Weinsch Engineering as a proprietary item.

—*mwj*—

17.5
KMC

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K-BAND STALOS

are on their way . . .

. . . to engineering development laboratories . . . to custom microwave system designers . . . and to wherever there is a need for dependable K-Band instrumentation!

And here is why — field-proven LFE Ultra-Stable Microwave Oscillators 814-K-21 and 814-K-22 span the K-Band spectrum . . . readily adapt to any custom system design . . . and are available now *when they are needed.*

MAJOR SPECIFICATIONS

Tunable Frequency Range
  Model 814-K-21 ....12.4 to 14.0 kmc
  Model 814-K-22 ....14.5 to 17.5 kmc
Power Output ....100 mw
Stability
  Short Term ....5 parts in 10^8
  Long Term ....1 part in 10^6
Dial Resolution ....1 mc
Dial Accuracy ....0.1% absolute

For complete detailed specifications ask for bulletins 814-K-21 and 814-K-22.

12.4
KMC

LFE

INSTRUMENT DIVISION

LABORATORY FOR ELECTRONICS, INC.

714 BEACON STREET • BOSTON 15, MASSACHUSETTS

WESTERN REGIONAL OFFICE, 211 South Beverly Drive, Beverly Hills, California.

Circle Reader Service Card 39

New Products

NEW LINE OF CRYSTAL MOUNTS NOW AVAILABLE

A new line of coaxial crystal mounts has been announced by Microlab, Livingston, N.J. These mounts are designed to accommodate almost all types of coaxial semiconductors and to provide a wide range of connector types, frequency ranges, and other characteristics.

In order to accommodate the wide variety of crystal cartridges in which semiconductor diodes are mounted, four basic types of mounts have been designed. These will hold the ceramic cartridges, small and large coaxial, and tri-polar types of crystals. They are equipped with a choice of N, BNC, TNC, C or HN male or female input connectors and BNC, TNC, or Microdot output connectors.

Internal DC returns covering the range from 30 to 13000 mc are available as well as a choice of output capacitances. Padded mounts, with attenuators built into the input can be supplied to provide a low input VSWR. Where maximum sensitivity is required, mounts tuned to a particular octave are also available.

A total of 6,250 combinations of crystal mounts are available for immediate delivery from stock. They are priced at $25 to $60 depending upon the required characteristics Full information can be obtained on request.

Circle Reader Service Card 100

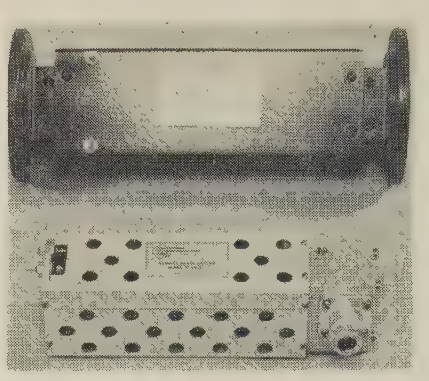
—*mwj*—

NEW Y-CIRCULATOR ELEMENTS AVAILABLE

New Y-circulator or isolator elements operating in the VHF-UHF region have been developed by the Research Division of Electronic Communications, Inc., Timonium, Md.

The elements are available at a specific frequency in the VHF-UHF region with the following characteristics: Band — 200 to 800 mc; Max. Isolation — 40 db; Max. Loss — 0.5 db; VSWR Max. — 1.1; and Peak Power (approx.) — 20 kw; the ambient temperature is 20 to 23°C.

These components will provide 20 db of isolation, with insertion loss not exceeding 1.0 db, over a frequency band of f_{max} = 1.3 to 1.5 times f_{min} if a variable magnetic field is applied. The VSWR over this band is not greater than 1.3. For a fixed magnetic field, the 20 db — isolation bandwidth decreases to the order of nine to 12 per cent of the center frequency.



Electro or permanent magnets can be supplied on request. (Similar isolator elements can be furnished for frequencies as low as 100 Mc or as high as 5000 Mc).

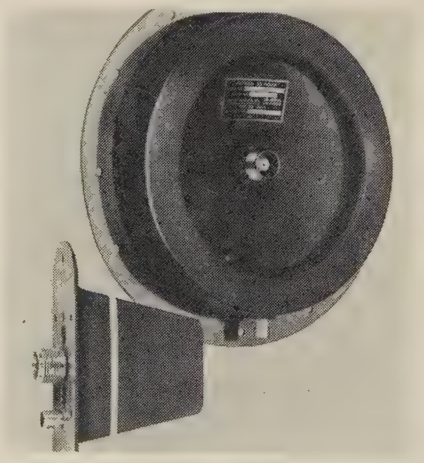
Circle Reader Service Card 101

—*mwj*—

L-BAND BLADE AND FLUSH ANTENNAS ADDED BY TRANSCO

Two L-Band antennas, the AT-740/A flush mounted and the new AT-741/A blade have been added to the line of airborne antennas produced for the aircraft and missile industry by Transco Products, Inc., Los Angeles, Cal.

Both antennas cover the 960 to 1200 mc frequency for IFF-TACAN and have a VSWR less than 1.5:1 from 1000 to 1100 mc. Each has a nominal impedance of 50 ohms and is vertically polarized. The BNC probe of each is approximately 18 db down. Both Transco antennas have HN connectors and meet MIL specifications. The blade type weighs 6.4 oz. while the flush mounted annular slot type weighs 12 oz.



Product data sheets with complete specifications, dimensional data, and other information are available on request.

Circle Reader Service Card 102

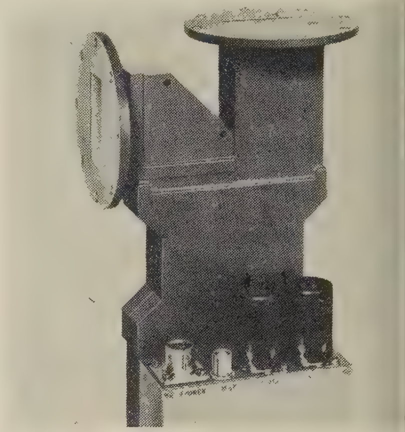
—*mwj*—

COMBINATION MIXER-PREAMPLIFIER DEVELOPED

A new 5.15 to 5.85 kmc. combina mixer-preamplifier for microwave guidance systems, developed by Microw Development Laboratories, Inc., Welles Mass., eliminates the problem of vari parameters resulting when separate mi and preamplifiers are combined. Ove mounting space is the same as that viously required for the mixer unit alo

The new MDL Model 187MB-360F1 tegrated mixer-preamplifier serves as a l noise, wide-band downconverter for ma and parametric RF amplifiers. Noise fig is less than seven db, with minimum g of 25 db.

The preamplifier is fix-tuned, with highly-effective stabilizing circuit t eliminates need for realignment after placement of tubes or crystal. Preampli output is precisely matched to fifty oh allowing the main amplifier to be remot located.



Circle Reader Service Card 103

—*mwj*—

GENERAL ELECTRIC ANNOUNC NEW PORTABLE THERMOCOUPL VACUUM GAGE

Improved appearance and a self-co tained rechargeable battery power supp are features of a portable thermocou vacuum gage recently announced by Ge eral Electric Co., Schenectady, N.Y.

The instrument can be operated for to 60 hours on its 1.3-volt nicket-cadmiu cell battery. Or it can be plugged into a 120-volt a-c outlet. In the latter case t battery is automatically recharged duri operation.

When operating on a-c, the gage is u affected by line voltage fluctuations, sin it continues to draw power through t battery.

New modern appearance is afforded a redesigned case and a G-E "Big Loo panel meter. The single meter combin both milliampere and micron scales, inc cated by two meters on other mode Scale selection is made by a three-positi switch: OFF, Milliamp, and Micron.

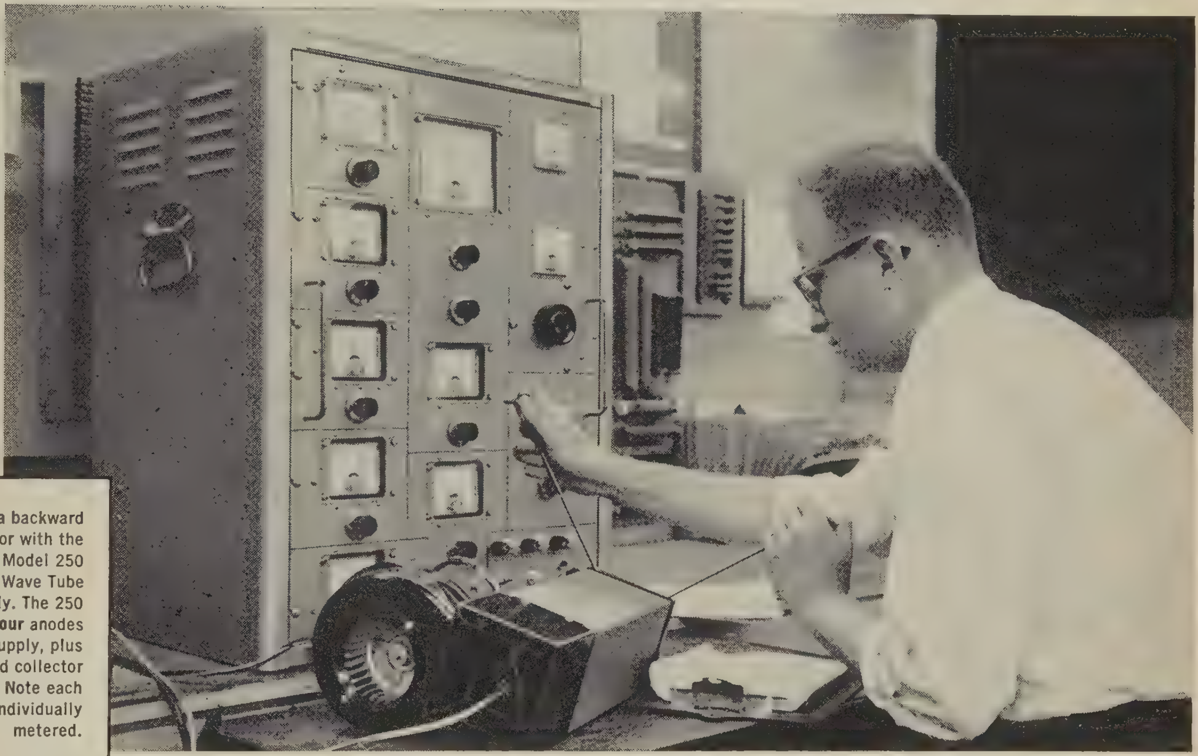
(*Continued on page 80*)

Power your TWTs and BWOs with the ALFRED 250

ALFRED's versatile Model 250 will operate more low-powered and low noise TW tubes than any other commercially available power supply. It operates most medium-powered traveling wave tubes as well. High regulation, low ripple and low drift make the Model 250 an ideal standard for testing and evaluating tubes, backward wave oscillators and carcinatrons.

Here's another remarkable feature: all electrode supplies are isolated from ground and connections brought out to rear patch panel. Most presently known grounding and modulation arrangements for TW tubes can be used.

Alfred's design protects both operator and tube. A "helix over-current relay" trips at full scale at any range and shuts off all high voltage supplies. All meters are isolated from panel for operator safety.



Aligning a backward wave oscillator with the Alfred Model 250 Traveling Wave Tube Power Supply. The 250 features **four** anodes and grid supply, plus helix and collector supply. Note each supply is individually metered.

TUBE EVALUATION

Send us your tube type specifications. Alfred Electronics will be happy to evaluate them and advise whether the Model 250 will operate your tube.

Alfred Electronics offers the industry's most complete line of packaged traveling wave tube amplifiers. Write for new short form catalog. Dept. 69

ALFRED ELECTRONICS
897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

BRIEF SPECIFICATIONS

HELIX SUPPLY	
Voltage	90 to 3500 v, range switch and 10 turn vernier
Current	0 to 5 ma to helix 0 to 60 ma to collector
External Modulation	Direct or capacitively coupled
PROTECTION	Overcurrent relay shuts off all high voltage supplies
COLLECTOR SUPPLY	
Voltage	0, +150, +250 v, relative to helix
Current	0 to 60 ma
GRID SUPPLY (relative to cathode)	
Voltage	0 to —150 v
Current	.1 ma average
External Modulation	Direct or capacitively coupled

ANODE SUPPLIES (relative to cathode)		
	#1	#2
Voltage	0 to + 450 v	0 to + 300 v
Current	0 to 20 ma	0 to 1 ma
	#3	#4
Voltage	0 to +750 v	0 to 2500 v
Current	0 to 1 ma	0 to 1 ma
HEATER SUPPLY		
Voltage	0 to 10 v ac	
Power	20 va maximum	
SOLENOID SUPPLY		
Voltage	0 to 100 v	
Current	0 to 7 amperes	
BLOWER SUPPLY		
Voltage	115 v ac or 28 v dc	
Current	0 to 1 ampere ac or dc	
PRICE	$1990 F.O.B. Palo Alto	

Circle Reader Service Card 40

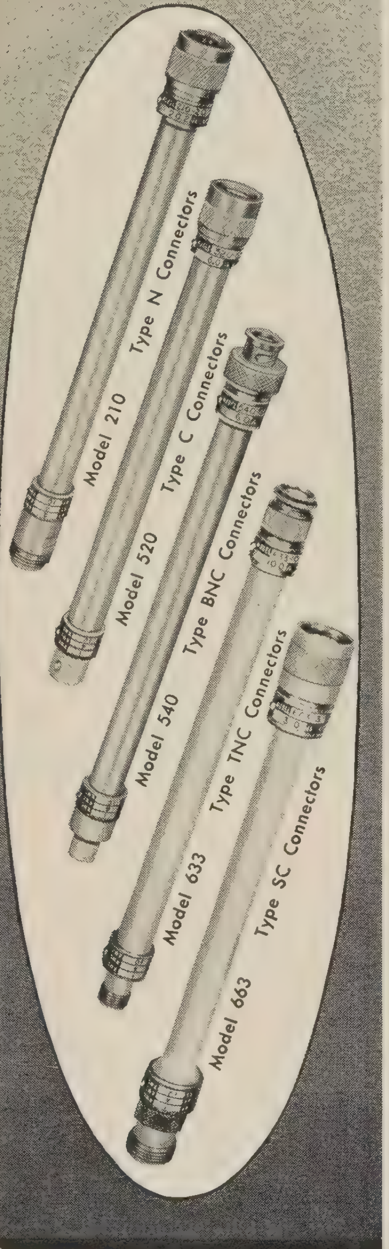
WEINSCHEL

FIXED COAXIAL ATTENUATORS

1 to 12.4 KMC

50 Ohms 1 to 20 db

Connectors: Type N, C, BNC, TNC or SC. Each type with male/female, double male or double female connectors. Made with Weinschel Film Resistors for maximum stability.



WE CO

Write for complete catalog, specifying frequency range of interest.

Weinschel Engineering

KENSINGTON, MARYLAND

Circle Reader Service Card 41

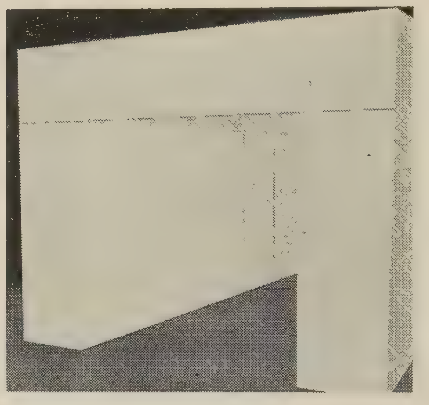
(*Continued from page 78*)

The new G-E instrument, calibrated from one to 1,000 microns, is designed for a wide variety of industrial and laboratory applications. Common uses are in vacuum systems for electronic tube manufacture, metalizing, heat treating, distillation, and dehydration. It is also widely used in conjunction with ionization vacuum gages and diffusion pumps to indicate when they can be safely energized.

Circle Reader Service Card 104

—*mwj*—

"BUILDING BLOCK" MICROWAVE ABSORBERS ANNOUNCED



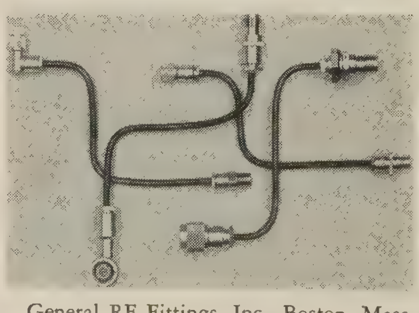
McMillan Industrial Corp., Ipswich, Mass., announces a new absorber for use in constructing free space rooms for testing of antennas at frequencies below 940 mc/s. Types BB and BP provide effective attenuation from 35,000 mc/s down to 50 mc/s in the case of the BB-96.

Major advantages are: (1) elimination of supporting structure — a cost reduction; (2) a new design principle permitting reductions in price per unit volume of absorber; (3) fire-resistant, rugged construction — floor blocks withstand 3000# p.s.f.; (4) reduction of shipping and storage space — in shipment they occupy a fraction of their installed volume.

Circle Reader Service Card 105

—*mwj*—

NEW SERIES OF TNC COAXITUBE CONNECTORS ANNOUNCED



General RF Fittings, Inc., Boston, Mass., producers of RF coaxial connectors, announces a new series of TNC Coaxitube (semi-rigid) Connectors.

These new TNC Coaxitube Connectors feature Collett clamp construction — a method of positive cable clamping so cables cannot turn or pull out.

Coaxitube Connectors are also availa in TM series — miniaturized versions TNC — for use where size and weight critical considerations.

The metal parts of all Coaxitube C nectors are silver plated; contacts have g plate over silver plate. All Coaxitube C nectors are available.

Circle Reader Service Card 106

—*mwj*—

NEW, LOW-COST, 60-FOOT SCATTER ANTENNA ANNOUNCED

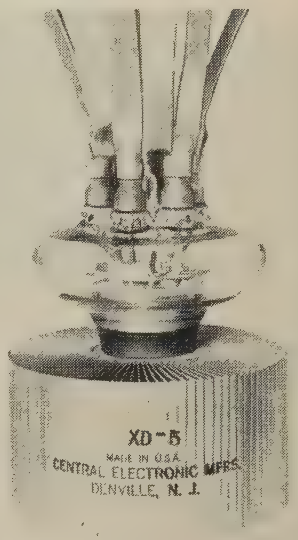
Antenna Systems, Inc., Hingham Ind trial Center, Hingham, Mass., announces new 60-foot low-cost scatter antenna. It fabricated out of galvanized steel to mi mize maintenance, and the overall des stresses maximum interchangeability a standardization of the various members. is easy to erect, is an all-bolted constr tion, and meets the necessary military s cifications.

Two models are available: a light d one that will withstand winds up to 1 mph with six inches of ice. A compl line of RF components is also available this antenna.

Circle Reader Service Card 107

—*mwj*—

NEW HIGH VOLTAGE PULSE TU ANNOUNCED



The Central Electronics Manufactur Division of Nuclear Corp. of America a nounces a new forced air cooled trio the XD-5. Specifically designed for pu operation, the XD-5 will switch 30 a peres at 40,000 volts with a duty of .0 This results in a peak power output 1.2 megawatts.

The XD-5 is available for immedi delivery.

Circle Reader Service Card 108

—*mwj*—

(*Continued on page 82*)

GOVERNMENT SURPLUS

K_a BAND RADAR SYSTEMS

34,860 MC. ± 348 MC.

35 — K.W. SYSTEM. RT-342 (XA-A)/APA-56 RF Head consisting of complete power supply, modulator, transmitter, duplexer and receiver. Using Sylvania Type 5789 Magnetron and Raytheon Type QK-291 Klystron. RF Output via RG-96/U Waveguide (.22" x .36" O.D.). Receiver utilizes Microwave Associates Type 1026 BR *Balanced Mixer*. Duplexer is Microwave Associates Model 1032 utilizing Type 5790 TR Type 5791 ATR. AFC Crystal Mount is Microwave Associates Model 1028. IF Amplifiers utilize subminiature tubes. Modulator is line type using hydrogen thyrotron switch tube. Output Pulse is .1 μ sec at 4,000 cycles. Power input to RF Head via Type AN connectors. Video and sync Output via Type BNC. These systems were manufactured by Westinghouse. All equipment is used, government surplus in excellent condition. All major components are guaranteed. Systems are complete with all tubes including TR, ATR, Magnetron and Klystron. Input Power 115/1/400 and 27 VDC.
(KaBS-064) Price: $1,500.00

Spare **#5789 MAGNETRONS.** Condition used, tested. Limited quantities available. Maximum of four per customer. Price, each when purchased with above system — $275.00. Price each purchased outright — $350.00.

K.W. SYSTEM. (Not illustrated.) Consisting of two units — Type RT-342)/APA-56RF Head with transmitter, duplexer, and receiver. Also Type -278/APA-56 Power Supply, modulator and local oscillator. Sylvania Type 9 Magnetron is used. All other specifications parallel above listed equipment.
k #(KaBS-065) Price: $3,500.00

Spare Modulator Type MD-278/APA-56. Excellent condition. All tubes included except Type QK-291 Klystron. Limited quantities available as spares when purchased with the above system.
Stock #(KaBS-066) Price: $250.00

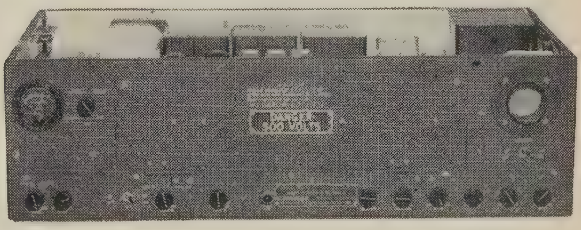
• • •

X-BAND RECEIVERS

8,500-9,600 MC. BALANCED MIXERS

NSITIVE X-BAND RECEIVER WITH DUPLEXING. Part of APS-C. An extremely modern well-designed X-Band receiver, featuring dual lance mixers for high sensitivity (—97 D.B.M. or greater). Normally ed to cover the frequency range of 8,500 to 9,600 MC. However, tual frequency coverage is much greater than this. 30-M.C. IF ip uses (8) 5654's with 3-MC Bandwidth. 1Q23 reference cavity for beacon. (1B63A), T.R., (1B35A), A.T.R., and (2) 2K25 klystrons as local oscillators. Tube compliment consists of 22 tubes plus 5 type 1N23B crystal diodes. Receiver includes self-contained A.F.C., beacon, and high level video output (6AG7). Output flange UG-40A/U. These receivers are new equipment spares, complete as described.
Stock #(XBS-059) (New in original packing) Price: $125.00

K-BAND RECEIVER. Model R-115/MPG-1. This receiver is ideally suited s a general purpose laboratory test receiver. It was normally used to cover he frequency range of 8,500 to 9,600 MC. However, its actual frequency overage is much greater than this. It is completely self contained and equires no external controls. Waveguide input and output via Type RG-52(½" x 1"). Normally used with 40 K.W. Magnetron (2J51). However, TR and ATR boxes will handle up to 100 K.W. duplexing. Receiver ntermediate frequency: 30 MC. Band width: 10 MC. Maximum gain: Approximately 1,000,000. This unit features AFC, crystal meter with witching, built-in A-scope (2"), I.F. Gain control, and manual tuning. Provisions for auxiliary external controls are provided for all functions. Power source required: 115/1/60. Receiver removed from Model MPG-1 adar system. All have been checked out and are in excellent operating condition.
Stock #(SBX-042) (Used-Excellent) Price: $295.00



ll equipment listed is U. S. Government urplus in new or excellent condition. Equipent is unconditionally guaranteed as decribed in this advertisement. All offerings e made subject to prior sale. Terms: %/10, Net 30 Days. F. O. B. point: Richond, California. All equipment will be hipped from stock.

RADAR DIVISION
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Cable: RADAR

Circle Reader Service Card 42

NO
TOOLING
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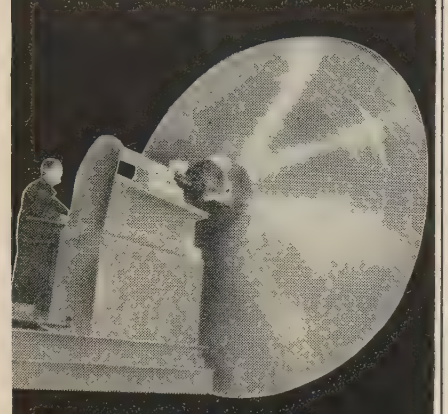

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C.W. Torngren Co., Inc., the largest manufacturer of spun aluminum parabolic reflector antennas in the country and originator of the exclusive Mecatorn® process, has machined and stocked permanent tooling for every diameter and focal length in popular use today. Reflectors can be Mecatorn® Powerspun from four inches to 12 feet in diameter.

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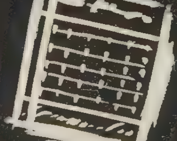


C. W.
TORNGREN
CO., Inc.
236 PEARL STREET
SOMERVILLE 45, MASS.

Circle Reader Service Card 43

New Products

(*Continued from page 80*)

LOW-COST TRAVELING-WAVE TUBE DEVELOPED BY SYLVANIA

Two new low-cost traveling-wave tubes for use in electronic test equipment and other commercial applications have been announced by Sylvania Electronic Tubes, Mountain View, Cal., a division of Sylvania Electric Products Inc.

Thomas D. Fuller, marketing manager of the division's Special Tube Operations, said the new S-band units (Types TW-4260 and TW-4261) employ permanent magnet focusing, "making them one-half the size and one-fifth the weight of equivalent solenoid focused types at no sacrifice in electrical characteristics."

Type TW-4260, Mr. Fuller said, has a minimum output power of one watt over the full 2-4 kilomegacycle octave. Type TW-4261 delivers 10 milliwatts minimum power and 37 db minimum gain over the same range. The tubes weigh three pounds and have a maximum diameter of 2-1/4 inches.

The small quantity price for both types is $925. Tubes for engineering evaluation are available for immediate delivery. Small quantities are available about 60 days after receipt of order.

In addition to the new units, two low-cost L-band types are now in development, and will be available in about two months, Mr. Fuller said.

Circle Reader Service Card 109

—*mwj*—

NEW C-BAND AND XB-BAND WATER LOADS ANNOUNCED BY SIERRA

The addition of new C-Band and XB-Band Water Loads to the Sierra 187 series of high-power, liquid-cooled, waveguide terminations has been announced by Sierra Electronic Corp., Menlo Park, Cal., a division of Philco Corp.

Covering frequency ranges of 5.8 to 8.2 kmc (Model 187 B-C) and 7.0 to 10.0 kmc (Model 1 1878-XB), these terminations are precision devices suited especially for Calorimetric RF power measurement applications as well as straight forward dummy loads.

The new terminations employ the ruggedized design of the Sierra 187 series to combine extremely low RF radiation and VSWR (max. VSWR of 1:10 and typical values of 1:05) with maximum reliability and power capability.

Unpressurized, Model 187B-C can be operated at average powers to five kw or peak powers to 500 kw, Model 187-XB is rated at three kw average power or 300 kw peak power. Both models can be pressurized to 45 psig to permit operation higher power levels.

All loads comprising the Sierra 1 series utilize a rigid, plastic water t mounted in a waveguide section and di onally oriented for impedance matchi An integral heater element is included permit accurate calibration of a cal metric power measurement system agai a low frequency standard.

Circle Reader Service Card 110

—*mwj*—

NEW BRANCHED COAXIAL LIN DUPLEXERS OFFERED BY BOMA

An addition to the microwave com nents line offered by Bomac Laborator Inc., Beverly, Mass., are the company's n branched coaxial line duplexers, utiliz two cell-type TR tubes and a single c type receiver protector tube.

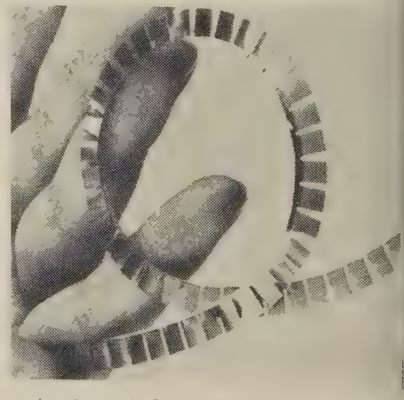
In the 3-1/8 inch unit there are t band pass filters, one in the receiver circ and one in the AFC pick-up circuit. Th are also directional couplers used for m suring transmitter power and antenna c cuit VSWR.

Coaxial branch line duplexers for ot frequencies and in other line sizes available on order.

Circle Reader Service Card 111

—*mwj*—

PHYSICAL FORM FOR BRAZIN ALLOYS DEVELOPED



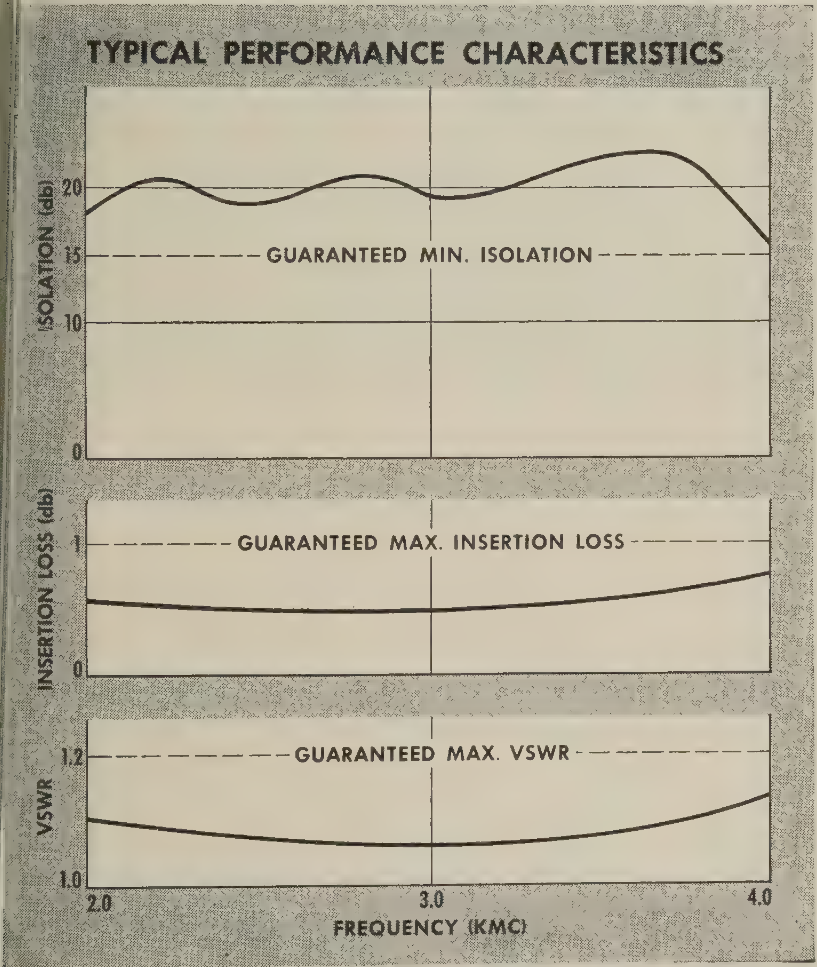
A physical form for brazing alloys been developed by Western Gold Platinum Co., Belmont, Cal.

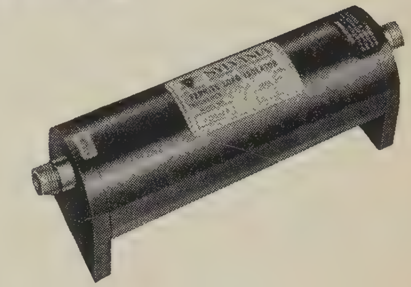
The new configuration, known as "W go Polyform," provides brazing convenie

(*Continued on page 88*)

Microwave Component News from SYLVANIA

Octave Bandwidth Coaxial Isolators from 1-11 kmc





BROADBAND coaxial ferrite load isolators from 1-11 kmc (with octave steps from 1 to 8) are now available from Sylvania for almost every microwave application. They are especially well suited to test equipment and other wide band applications.

Operating curves for an FD-151P, shown at left, illustrate the outstanding performance of these units. In each case, operation exceeds the rated limits by a substantial margin throughout the entire band—not just at mid-band.

With normal handling, Sylvania ferrite isolators give this same electrical performance for years without deterioration or failure. They can be used to reduce the VSWR presented by a load or antenna, and to protect oscillator output from long line effects.

For more information on these units or other standard or custom built devices in Sylvania's extensive ferrite device line write, wire or phone your nearest Sylvania tube sales office, or contact Sylvania Special Tube Operations, 500 Evelyn Avenue, Mountain View, California.

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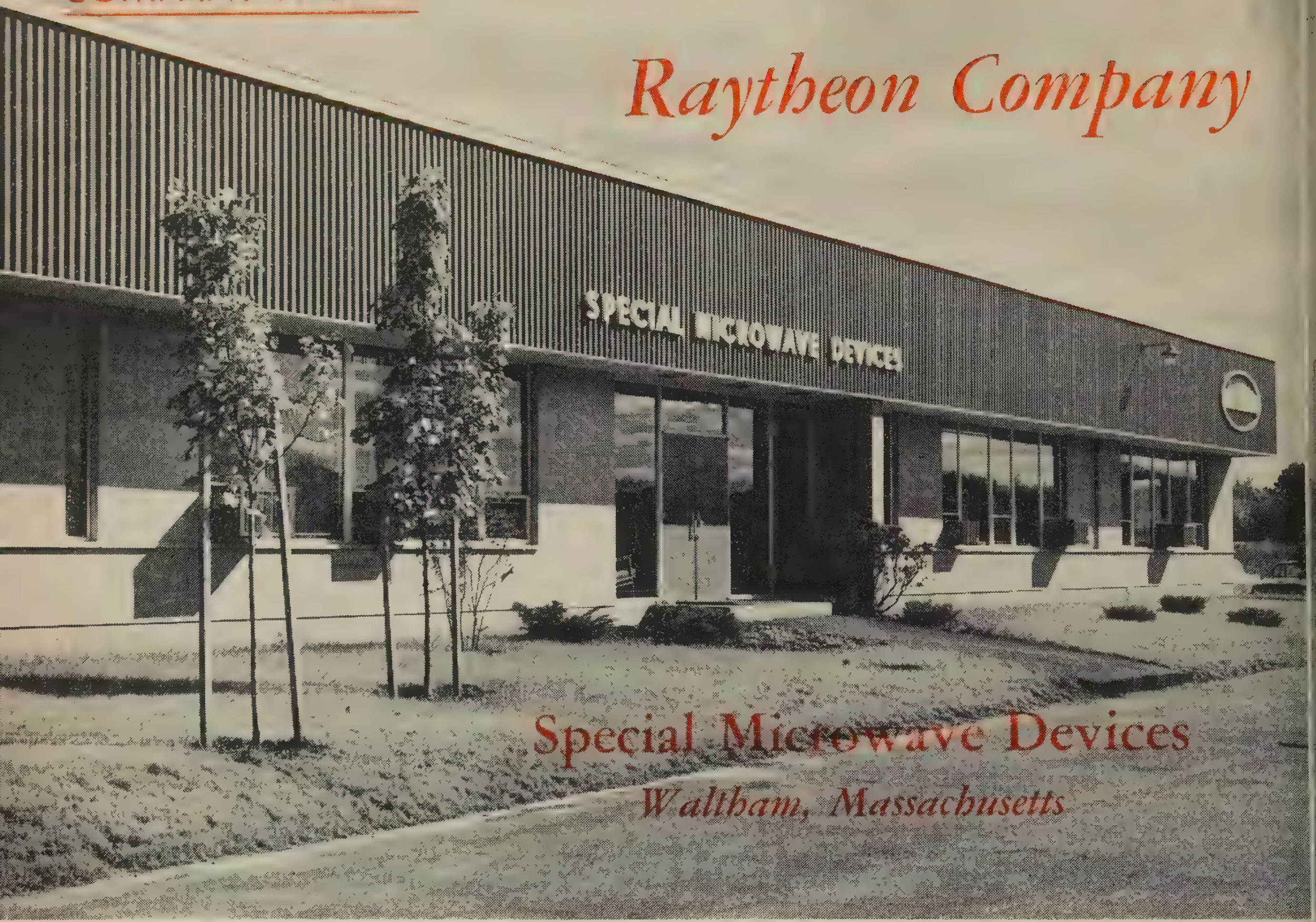
COMPANY PROFILE

Raytheon Company



Special Microwave Devices

Waltham, Massachusetts

Raytheon originally embarked on the development and production of ferrites and ferrite devices nearly ten years ago to meet its own systems needs. Various components groups throughout the company organized their own task forces to develop ferrite devices for particular systems. Within a few years, each of these separate, specialized groups demonstrated marked success in solving its own problems. Over-all, these groups built up a highly valuable but still uncoordinated body of know-how in ferrite devices covering a wide range of functions, power levels, and frequency bands.

In 1956 Dr. Howard Scharfman, who had headed ferrite development in the Missile Systems Division, established in the Research Division the nucleus of an integrated microwave devices group to develop, produce, and market a comprehensive line of ferrite materials and devices.

As markets have developed, more senior people have joined the Operations to head up new sections until now there are two electrical design groups, one mechanical design group, a materials development group, a product engineering group and a rapidly expanding production organization. The original three-man staff has now grown to more than 100.

Today this activity is housed in its own facility, a recently completed 30,000 square-foot laboratory on Route 128 in Waltham, Massachusetts. Nearly one-half of this area is devoted to development of materials and devices; the remainder provides flexible production space as well as administration and sales offices.

Early History

The growth of the Special Microwave Device Oper tions like that of most new product activities in both sma and large corporations has stemmed from a market nee and a group of men who knew how to meet it. Dr. Schar man himself had been working in all phases of ferrite d vices and materials since joining Raytheon in 1954. Pr viously, he had gained wide knowledge of microwav components and systems at Boeing Airplane Co., where h did research and development on receivers, antenna pa tern ranges, and aircraft antennas; and at the Johns Hop kins Radiation Laboratory, where he worked on UHF an VHF circuits and microwave scattering problems whil completing studies for his DSEE degree. He holds a grou of patents for microwave devices and has contributed man papers on the subject.

Recognizing the close interdependence of systems an components designers, Dr. Scharfman has made it a firr policy to base all advertising or proposal claims o proven performance or realistic development possibilitie He also believes that a perceptive management is essen tial in building the personal enthusiasm, flexibility, an group morale associated with successful new businesse while at the same time retaining the long-range goals an financial advantages of a large company.

The technical director, Dr. Colin Bowness, joined th group in early 1957. He came from the Microwav Laboratory of Electrical and Musical Industries in Felt ham, England, where since 1951 he had been director of laboratory carrying out research and development on range of microwave components and systems. Dur- this period he had also been engaged in research work he Physics Department of Birkbeck College, London, ying the scattering of electrons and positrons. For work he received his PhD degree from the University ondon in 1956. Dr. Bowness also holds a group of nts covering the design of ferrite devices and has tten several important papers on the subject.* He is ssociate of the Institute of Physics and a member of IRE.

ducts and People

One of the first projects of the Operations was the iaturization of rotational isolators. Although rotational ators were available, they were not small enough for jected airborne systems, especially in missile applica- ns. Beginning in 1957, Dr. Scharfman and Dr. Bow- s developed units which could be coupled to conven- nal waveguides at any desired orientation. These iso- rs, by the use of twist irises and special matching tech- ues, permitted rotation to any angle without signifi- t increase in unit length. Concurrent environmental rk provided greatly increased resistance to humidity, perature and shock. Initial work was at X-band with sequent development providing some 30 models in ious frequency bands.

About the same time, experiments got underway to ize new materials coming out of the Research Divi- n. This program, conducted in cooperation with Ray- on systems engineers, was aimed at finding ways of dling high power in low-frequency isolators and cir- lators. Initial efforts were applied to L-band isolators eded for longer-range detection and tracking radars, nce high-power L-band tubes were already available.

Much of this work was directed by John Q. Owen, a nior engineer who came to Raytheon from Westinghouse ectric Corporation in Baltimore, where he had worked high-power antenna feed systems and diplexing filters r a high-power, low-frequency radar. In addition, Ta- eusz Rogala was instrumental in designing most of the omplex mechanical structures required for high-power nits. An early addition to the group, he came to Raytheon in 1957 with a broad background in mechanical ngineering and machining.

High-power S-band isolators and circulators were being eveloped concurrently by Daniel Masse, who also joined aytheon in 1957. He came from CSF in France, where e had been working with low-frequency microwave components. His S-band circulator was later tested up to five negawatts peak power and 14 kilowatts average power as oon as such powers became available with the advent of aytheon's Amplitron.

The work in S- and L-bands led to pioneering in UHF solators, first at 600 megacycles and 350 megacycles and ecently in an isolator covering an octave bandwidth from 00 to 400 megacycles at an average power of 15 kilo- vatts. This last development was made possible by de- ising special transmission lines, a significant advance in he state-of-the-art.

Concurrent with the UHF isolator developments, a rastic reduction in the weight of high-power circulators vas achieved by using special ferrite materials and designing for operation below resonance. Initial work was at L-band for peak power to five megawatts, and average power to 10 kilowatts. Raytheon is also working on isolators which will handle 100 kilowatts average power in the 450-megacycle region, as well as super-power devices in other bands.

Management team of Special Microwave Device Operations includes, left to right, Howard Scharfman, operations manager; Eugene Slotta, manufacturing manager; Colin Bowness, engineering director; and Ralph Moschella, marketing manager.

Several other Raytheon "firsts" during 1959 helped build the company's reputation with systems designers. The first commercially available miniature Y-circulators at X-band were followed by the first coaxial low-loss Y-circulators as well as extremely low-loss circulators in L-band and UHF. Heading up this new area, which also includes responsibility for all S-band and C-band research and development activities, is Basil Vafiades. He came to Raytheon in the summer of 1959 from Microwave Associates, where he had been a senior engineer responsible for development of ferrite devices and high-power TR tubes.

The broad line of low-frequency Y-circulators whose development he supervises, feature insertion loss in the vicinity of 0.3 db. Devices of this kind are becoming increasingly important to those working with parametric amplifiers and masers in radio astronomy. Complex cooling techniques have also led to unique high-power circulators in X-band and C-band which will handle up to 20 kilowatts of CW power. Recent circulator development work has centered on further miniaturization and broadbanding.

Materials Laboratory

Materials research has been a vital factor in the development of new devices. The drive for high-power handling capability, miniaturization, low-insertion loss and other desirable characteristics was founded on new materials formulated in Raytheon's Research Division.

In 1958 a special laboratory for the development and production of ferrite materials was set up under William R. Griffin, a senior ceramicist who had received extensive experience with Aerovox Corporation as group leader in the development of both titanate and ferrite compositions.

Originally located in the Research Division to permit close coordination and utilize existing equipment, the ferrite materials laboratory was moved to the Operations' new plant upon its completion in February, 1960. How-

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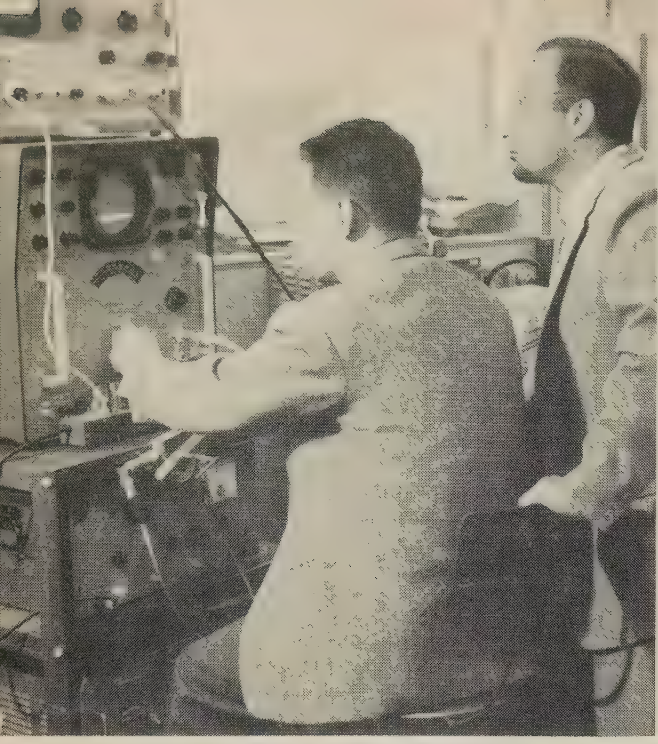
* Including "Microwave Ferrite Devices and Their Applications," a widely-read survey article which appeared in the first issue of "the microwave journal."



This newly established parametric devices development laboratory will add a new dimension of capability to Raytheon's Special Microwave Device Operations.

ever, this laboratory continues to work closely with solid-state materials specialists in the Research Division.

Laboratory facilities include mixing and ball milling equipment, extrusion and form presses, as well as firing, calcining, and sintering kilns. There are also complete facilities for making both physical and electrical tests on materials samples. The laboratory is thus equipped to provide uniform materials for all of Raytheon's special microwave devices, in both development quantities and high-volume production. Materials are also sold direct to outside customers.

Marketing Philosophy

While materials researchers and development engineers were advancing the state-of-the-art and developing special units to meet customers' exacting specifications, Ralph M. Moschella, marketing manager, who had joined Raytheon in 1953, was applying to ferrite devices his wide experience gained in the marketing of various Raytheon product lines.

From the inception of the ferrite group it has been Raytheon's philosophy that the real market for ferrite devices lies in filling the specific needs of systems designers. For this reason, the marketing effort has been directed both towards meeting expressed needs and towards pointing out unrecognized ones. It has often been necessary to convince system designers not only that ferrite devices can perform unique functions but that they can do certain other jobs better than existing devices.

For instance, it is well known that ferrite isolators can provide a constant load impedance which keeps tube output constant and protects the tube in the case of high-power applications. Another example is that circulators can replace TR or ATR tubes in many circuits, and being passive units, they avoid both replacement and recovery-time problems. However, in the case of coaxial Y circulators, a new market need was envisioned and a complete line developed. The result was widespread acceptance
systems designers.

By taking units developed for special systems nee
simplifying the packaging, and incorporating more g
eral features, the Operations has built up a complete l
of approximately 150 ferrite devices which include i
lators and circulators from UHF to K-band, as well
switches and broad-band modulators. Because detailed
sign data exists on all of these products, Raytheon c
customize to exact specification with very little lost ti
or effort. Such customized devices obviously offer far b
ter performance in a particular systems application th
do the typical specification of a standard unit.

Another important facet of the marketing philosop
has been to stand back of all commitments made to c
tomers. This necessitates an engineering evaluation of t
customer's *actual* needs in relation to the state-of-the-a
Systems requirements can often be met with devices
quiring little development expense or with devices th
are simpler than had been envisioned in the origi
specifications. Raytheon's responsibility is not merely
meet specifications but to deliver the device that will
a particular job as efficiently and economically as possib

Production

As systems requirements moved from the prototy
stage into full-scale production, the production depa
ment shifted into high gear. The Operations' new facili
includes 15,000 feet of production space with the pr
duction control and purchasing functions directly adjace

Heading up this area is Eugene Slotta, a manager wi
long experience at Raytheon and other companies in t
production of microwave components. His previous Ra
theon assignment was as superintendent of manufacturi
for the Government Equipment Division.

A complete quality assurance system is administered
Joseph Bolus, the Operations Production Engineering Ma
ager. Formerly with Technicraft, he is a senior micr
wave engineer and an authority in development and pr
duction methods.

Looking Ahead

In three years the Special Microwave Device Oper
tions has built up a complete line of ferrite devices i
cluding isolators and circulators from UHF to K-band,
well as switches and broadband modulators. In addition
future expansion of this established line, a new dime

Members of Raytheon's Special Microwave Device Operation
discuss a technical proposal. Left to right are: Joseph Bolus
production engineering manager; James Cauger, field sales administrator; Tadeusz Rogala, senior mechanical design engineer; and Charles Freed, head of the Parametric Devices Department.

luating new ferrite materials for device applications are, to right, William Griffin, senior ceramicist; John Owen Basil Vafiades, senior engineers.

n of capability will be added with the introduction of ametric devices. Charles Freed, a senior engineer with g experience in parametric amplifiers and related de- opments, is heading up a new department to integrate exploit Raytheon's knowledge in this field.

n keeping with its philosophy, the Operations will be content merely to develop and produce parametric ices as such. The goal is to offer integrated packages sisting of parametric elements along with the ferrite ces and microwave tubes needed to achieve optimum ems performance.

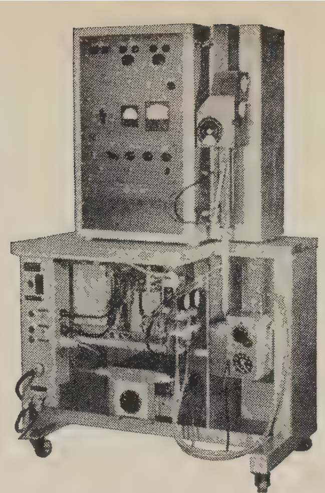
anization

ioneering a product line in a new field is no easy ertaking. Raytheon's approach to the problem was to l the right man to do the job — Dr. Scharfman — and n to nurture his group in the creative, unregimented at- sphere of the Research Division. Not until the group s well established, had developed successful products prove its competence, and had become known among tems designers was it transferred to a commercially ented division. Here it could flourish through the use facilities designed to increase production efficiency and ve an industry-wide market.

The Special Microwave Device Operations is now a part Raytheon's Microwave and Power Tube Division, but h its own separate plant and organization. This gives tomers the advantage of close cooperation in the de- n of subsystems incorporating both tube and ferrite ices.

Engineering support is available not only from micro- ve tube specialists within the division but also from anced development groups in Raytheon's various sys- ns divisions. Close contact is also maintained with ntists in the Research Division who are conducting ic studies in ferrite materials. Thus, the Operations is ally situated to serve both as the focal point and the ring house for information on problems involving fer- e devices and related microwave components. This erplay of ideas among a large and widely experienced up of engineers and scientists has helped push Ray- on ferrite device development at an ever increasing e.

n brief, Raytheon's Special Microwave Device Opera- ns is not only strong in its own right but can com- nd the technical assets of a corporation whose interests ge over the entire spectrum of the electronics industry.



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Measures dielectric constant and loss over a wide temperature range at 1, 3, and 8.5 kmc.

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Accessories now available: *Temperature Control Unit.* Enables dielectric properties of solids to be measured at any temperature between −30°C and +500°C; liquid samples to +150°C. Includes waveguide extension and sample holders for solids and liquids.

Room-Temperature Extension Sample-Holder. For measuring liquids or semi-solids at room temperature only.

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For brochure giving details and specifications, write:

Central Research
laboratories, inc.
Dept. 203 — Red Wing, Minnesota

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(*Continued from page 82*)

and economies in a wide range of applications, particularly in laboratory and production brazing of vacuum-tight seals for electronics.

Since the L-shaped Polyform strip is slotted along its widest dimension, it can be bent around virtually any contour. It thereby forms round, rectangular, oval or any other shape of brazing alloy desired. Its principal economic advantage over conventional punched washers is the elimination of scrap, which is particularly beneficial in precious metal alloys. It also eliminates the necessity for special tooling to produce unconventional shapes.

The Polyform strip can be supplied in thicknesses down to .002 inch. The width of the serrated or punched out section can be varied from 1/8 to 3/8 inch in 1/64 inch increments.

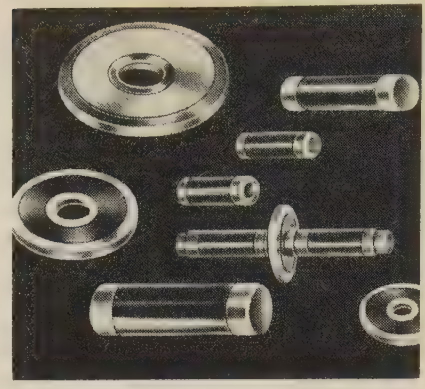
Polyform is available in all of the low vapor pressure brazing alloys offered by Western Gold & Platinum Co., specialists in high alumina ceramics and precious metal alloys for vacuum tube and semiconductor applications.

Circle Reader Service Card 112

—*mwj*—

THIN-FILM RESISTORS PROVIDE PRECISION AND RELIABILITY

Film Resistors, Inc., Morristown, N.J., announces production of a new line of thin-film carbon resistors specially designed for use in microwave attenuators, precision coaxial terminations, dummy loads, coupling loops and other special applications.



These new FRI components offer excellent high frequency characteristics and stability. Pyrolytically deposited films on selected substrates are completely protected with special epoxy resins. Extremely thin films and lack of spiralling, result in minimum inductances. FRI provides tight tolerances (± one per cent standard), high reliability and economy in standard or special disc and rod types.

Circle Reader Service Card 113

—*mwj*—

NEW UHF BEAM POWER TUBE JOINS RCA "CERMOLOX" LINE

A new, forced-air-cooled, ultra-high frequency beam power "Cermolox" tube has been introduced by the RCA Electron T
Division, Harrison, N.J.

The small tube, RCA-7649, is desig
specifically for pulse applications wh
dependable performance under severe sh
and vibration is essential, according
C. E. Burnett, Division Vice Presid
Industrial Tube Products Department.
is intended for use in grid-and-scre
pulsed and plate-and-screen pulsed ra
frequency oscillator and amplifier ser
at frequencies up through 2000 meg
cles in compact airborne, mobile and fi
equipment.

The new tube can be used to drive
recently announced RCA-7651, anot
Cermolox type. When used under c
tinuous commercial service conditions a
plate-and-screen-pulsed rf amplifier i
cathode-drive circuit at 1215 megacy
with a 10-microsecond pulse duration
0.01 duty factor, the 7649 can deliver a
4500 watts of useful power at peak
pulse with a driver power output of a
450 watts at peak of pulse.

Circle Reader Service Card 11

—*mwj*—

NEW HIGH TEMPERATURE DIELECTRIC DEVELOPED

The development of a new high t
perature permeable dielectric that is
to operate continuously in a tempera
environment exceeding 400°F has been
nounced by Custom Components,
Caldwell, N.J. It is designated CMA-

This dielectric according to H. I. I
ziger, president, is formulated out
powdered iron in a special resin-base
mulation that is suitable for operatio
a microwave absorber in a number
modern and exotic circuit applications.

The material is easily molded or
chined to shape, and custom shapes
close tolerances are available from the
tory. The finished shapes are used as
minations, dummy loads and for sin
microwave applications.

Circle Reader Service Card 11

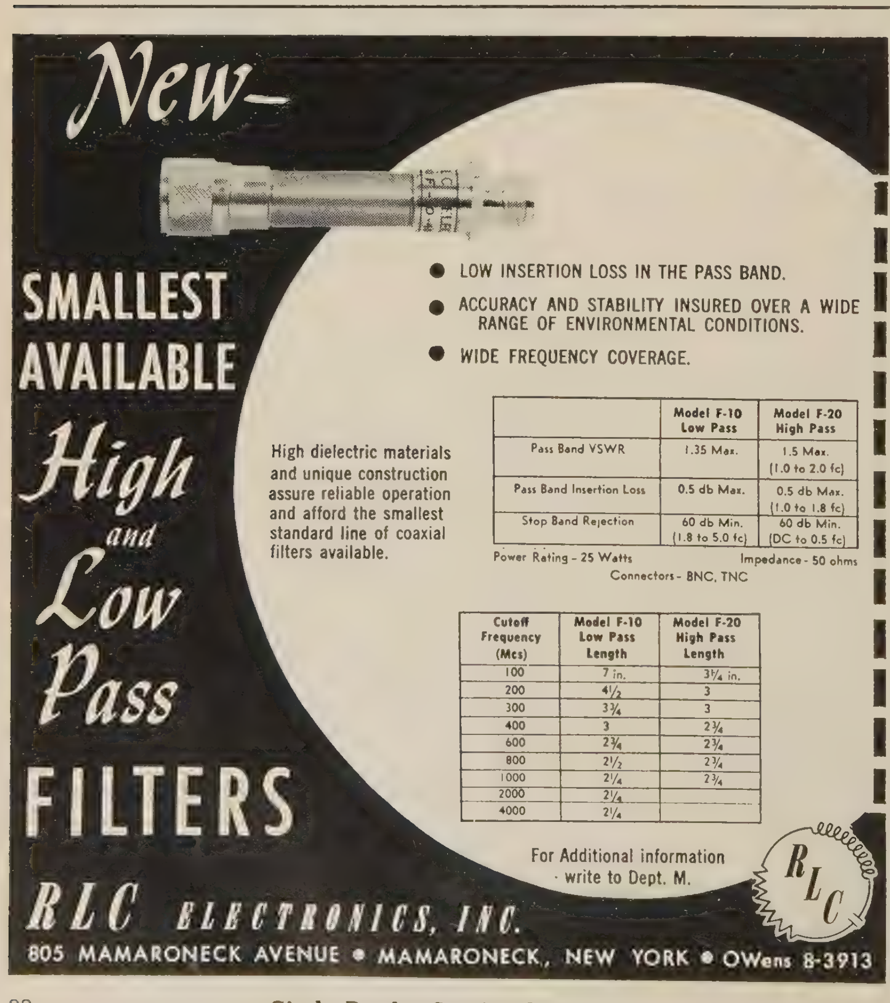
—*mwj*—

ALL-METAL VALVE FOR HIG VACUUM SYSTEMS DEVELOPE

An all-metal valve for high vacuum,
metal systems has been developed by K
Engineering Laboratories, Palo Alto, C

The new valve, especially applicabl

(*Continued on page 90*)



New—

SMALLEST AVAILABLE

High and Low Pass FILTERS

- LOW INSERTION LOSS IN THE PASS BAND.
- ACCURACY AND STABILITY INSURED OVER A WIDE RANGE OF ENVIRONMENTAL CONDITIONS.
- WIDE FREQUENCY COVERAGE.

High dielectric materials and unique construction assure reliable operation and afford the smallest standard line of coaxial filters available.

	Model F-10 Low Pass	Model F-20 High Pass
Pass Band VSWR	1.35 Max.	1.5 Max. (1.0 to 2.0 fc)
Pass Band Insertion Loss	0.5 db Max.	0.5 db Max. (1.0 to 1.8 fc)
Stop Band Rejection	60 db Min. (1.8 to 5.0 fc)	60 db Min. (DC to 0.5 fc)

Power Rating - 25 Watts
Impedance - 50 ohms
Connectors - BNC, TNC

Cutoff Frequency (Mcs)	Model F-10 Low Pass Length	Model F-20 High Pass Length
100	7 in.	3¼ in.
200	4½	3
300	3¾	3
400	3	2¾
600	2¾	2¾
800	2½	2¾
1000	2¼	2¾
2000	2¼	
4000	2¼	

For Additional information · write to Dept. M.

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805 MAMARONECK AVENUE • MAMARONECK, NEW YORK • OWens 8-3913

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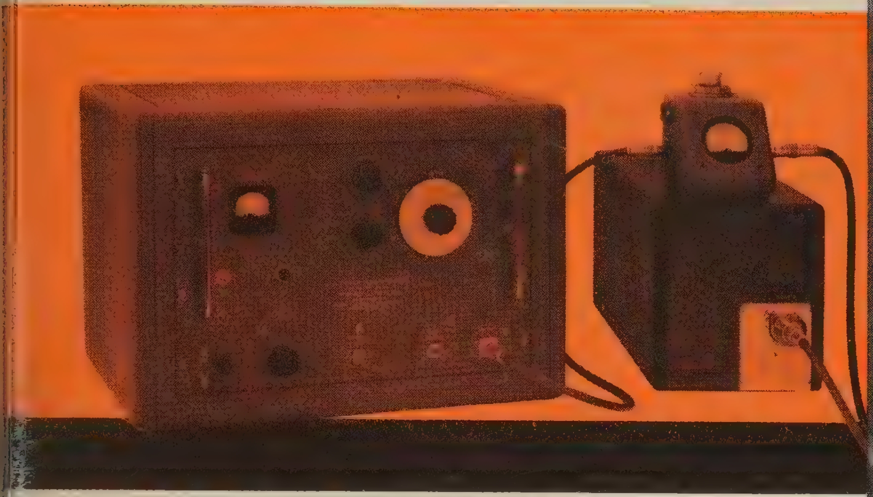
Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!



Sierra 290B Test Set

equency coverage dc through 12.4 KMC.

Guaranteed power measuring accuracy of 1%. Probable accuracy better than 0.5%. Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

Data and prices subject to change without notice. Prices f.o.b. factory.

Laboratory setup above shows Sierra Model 215 Power Source being used in conjunction with Model 290B Calorimeter to calibrate Sierra Bi-Directional Power Monitor. Designed specifically for calibration purposes, 215 series Sources include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C, 150 to 470 MC; Model 215D, 470 to 1,000 MC. Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

IERRA ELECTRONIC CORPORATION
A Division of Philco Corporation
60C BOHANNON DRIVE • MENLO PARK, CALIFORNIA • DAvenport 6-2060
Sales representatives in all principal areas
Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.
Export: Frazar & Hansen, Ltd., San Francisco, California.
6560

sierra

Circle Reader Service Card 47

SOLID STATE FRONTIERS

C-BAND CIRCULATOR

Lightweight, compact and with high performance over a broad range of temperature, Motorola C-Band Circulators were designed for – and are providing – high levels of efficiency and reliability in today's most advanced military electronic equipment.

Equally applicable to nonmilitary systems, these Motorola ferrite circulators operate from 5400 to 5900 mc with insertion loss of less than 1.2 db. Isolation, in both the transmit and receive modes, is more than 12 db over the entire frequency band and over a temperature range of 0° to 85°C, or 0° to 105°C, depending on model.

Experience-proven in critical applications – in missile-borne radar transponders, for example – these highly efficient ferrite devices when used in conjunction with a preselector provide isolation from antenna mismatches, eliminate need for switching gas tubes, and perform duplexing functions, even for CW systems.

Whether your specifications demand smaller size and lighter weight, better isolation, or elimination of separate transmitting and receiving antennas, we suggest that you investigate all the advantages that this Motorola solid state device offers to modern microwave systems planning. Full specifications and details upon request.

REPRESENTATIVE MOTOROLA SOLID STATE DEVICES

ISOLATORS • CIRCULATORS • PARAMETRIC AMPLIFIERS • SWITCHING CIRCULATORS • HIGH-SPEED, BROAD-BAND SWITCHES • PHASE SHIFTERS •

For detailed information, write:

MOTOROLA INC.
Solid State Electronics Department
8201 East McDowell Rd.,
Scottsdale, Arizona WHitney 5-6311

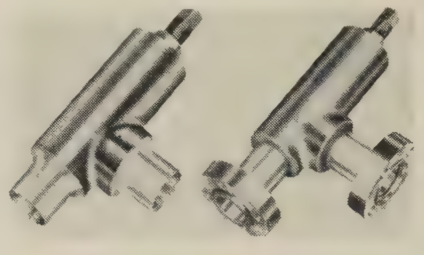
Circle Reader Service Card 48

New Products

(*Continued from page 88*)

ion gettering pumps and usable on oil diffusion type vacuum systems, provides a reliable vacuum seal with an easy, minimum pressure, manual operation.

Valve construction, with the exception of the seating material, is of 300 series stainless steel, inert gas welded. The seating material is a very low vapor pressure metallic alloy. Designed for operation up to 120°, the valve can be baked-out to 450°, and operates in a pressure range from atmosphere to below 10^{-10} mmhg.



The valve seating arrangement provides unlimited vacuum tight closures; no vacuum outgassing of the seating metal is necessary to remove trapped residual gases normally found in organic seating material.

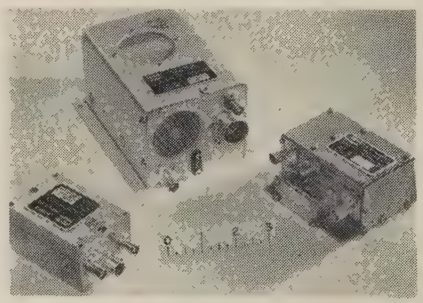
The Kane all-metal valve is available in one-inch, four-inch and 6-inch diameters, and can be furnished with flanges to fit all standard vacuum fittings. The one inch valve (without flanges) is priced at $380.00 f.o.b. Palo Alto. Further size, accessory and price information furnished on request.

Circle Reader Service Card 116

—*mwj*—

NEW LINE OF POWER AMPLIFIERS PRODUCED

United Electrodynamics, Pasadena, Cal., features a complete family line of rf power amplifiers for use in the 215 to 260 mc telemetry frequency range. Now in quantity production, the power amplifiers are being used in such missiles as Minuteman and Hound Dog, and in space programs Midas and Samos. Output power of 10 watts to 100 watts may be obtained with two-watts rf drive.



Model PA-10 features a nominal 10-watt output and is the smallest and lightest amplifier available. Model PA-11 has 10 to 25 watts output with no cooling required. Model PA-14 has a self-contained blower for 100-watt operation.

Circle Reader Service Card 117

—*mwj*—

VARIAN DEVELOPS AUTOMAT VACION® HIGH VACUUM SYST

A completely automatic VacIon® hi vacuum pumping system has been nounced by Varian Associates, Palo A Cal.

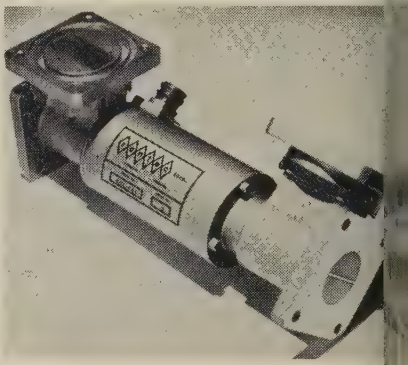
Manipulation of a single push-but control starts an automatic pumping c that will reduce the pressure in a bell shaped chamber from atmospheric p sure to 10^{-8} mm Hg. (equivalent to altitude of 1,000,000 feet). Upon con sion of the high vacuum experiments processes, the return of the chamber atmospheric pressure is also accomplis automatically.

The heart of the new system is a Vac high-vacuum pump with a pumping sp of 1,000 liters per second. Addition the automatic operation to the many o advanced features of the electronic Vac high vacuum pump makes it useful space research, for processing transis and other semiconductor components, evacuating electron tubes and for o high vacuum applications.

Circle Reader Service Card 11

—*mwj*—

RANTEC INTRODUCES NEW FERRITE SWITCH



Rantec Corporation, Calabasas, C announces the design of a new fast- time, low-switching-speed ferrite sw The difficult problem of fast switc time with long dwell time has been so with the Rantec Model SXL-141 fe switch and the Rantec Model DS driver. This combination is capable simultaneous SPDT switching and dup ing of received signals.

Circle Reader Service Card 11

—*mwj*—

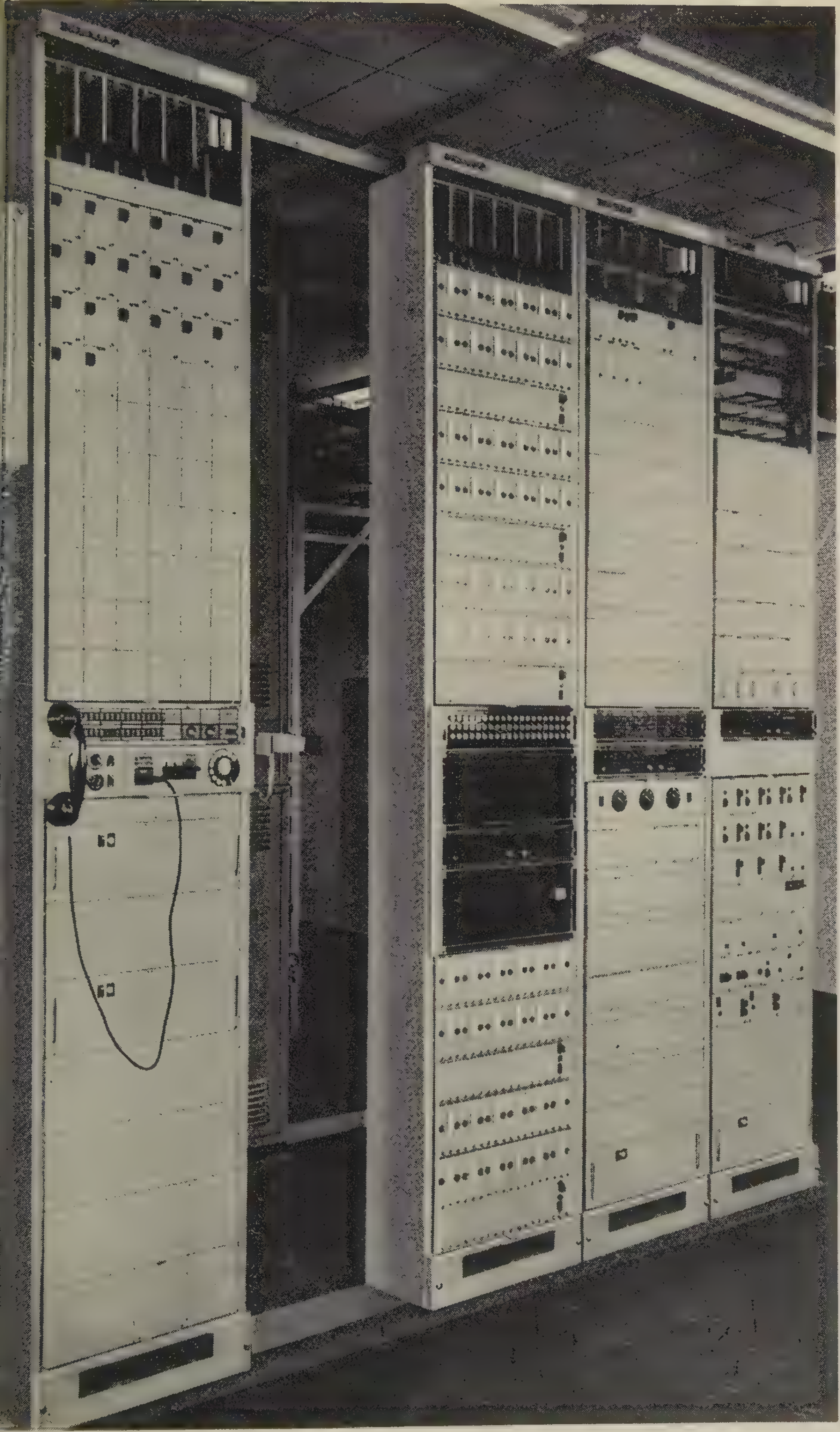
POWER SUPPLY DESIGN FOR AUTOMATIC MICROWAVE COMMUNICATIONS ANNOUNC

A new no-break isolated power su design, engineered to meet the exacting mands for automatic operation of munications equipment in remote locat has been announced by Freeport Engin ing Co., New York, N.Y.

The continuous power supply units posed by Freeport Engineering have designed for automatic operation at

(*Continued on page 92*)

NEC microwave carrier terminal equipment with transistor reliability



-bay array of NEC 120-channel terminal equipment for microwave links

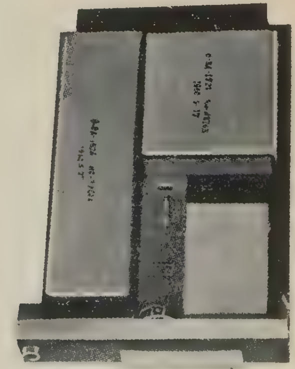
This fully transistorized carrier telephone equipment for microwave links provides 120 toll quality telephone channels. Characteristics meet or surpass all CCITT requirements.

It offers these advantages over conventional tubed equipment :

- 90% reduction in power consumption
- Lower operating temperature
- Less floor space
- Increased reliability, resulting in lower maintenance costs.

Each 300 – 3,400 c/s telephone channel can accommodate 24 voice-frequency telegraph channels operated at a keying speed of 50 bauds.

NEC will also make available within this year 600-channel transistorized equipment.



A part of print-wired channel translating unit

NEC Communications Systems / Electronics
Nippon Electric Co., Ltd. Tokyo, Japan

Circle Reader Service Card 49

New Products

(*Continued from page 90*)

tudes up to 10,000 feet with ambient temperatures down to zero degrees contigrade.

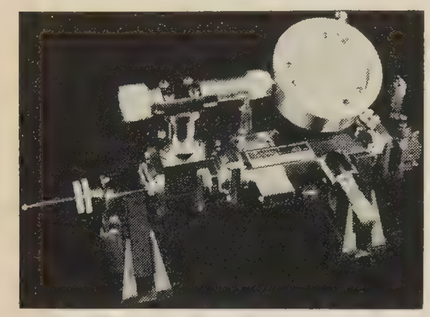
Electrical ratings of the proposed units range from 15 to 25 kw. They are driven by air-cooled diesel engines with three, four or six cylinders, depending on alternator output and altitude at installation.

No-break operation is assured by a system of coordinated mechanical, electrical and hydraulic controls that permit regulation of power supply within very close voltage and frequency limits.

Circle Reader Service Card 120

—*mwj*—

MICROMEGA INTRODUCES FIRST OF PARAMETRIC AMPLIFIER LINE



Micromega Corp., Venice, Cal., has just introduced the first of its line of parametric amplifiers, the S-Band Model S1000. Typical specifications include a tuning range of 100 mc, operating gain of 17 db, bandwidth of 20 mc (at three db points), and a system noise figure of 2.5-3.0 db (operating into a mixer with a noise figure of 10 db).

Micromega's parametric amplifier assembly consists of a three-port ferrite circulator, a reflection-type diode amplifier, a pump klystron, a variable attenuator and a directional coupler monitor. For some applications, ferrite isolators may be necessary between the antenna and the circulator and/or between the circulator and the mixer. Micromega engineers will custom-design these amplifiers to optimize the electrical characteristics most important for specific systems applications.

Circle Reader Service Card 121

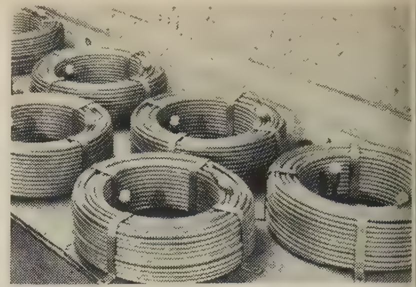
—*mwj*—

AMERICAN TUBE BENDING DEVELOPS COMPACT DELAY LINES

The Electronics Division of the American Tube Bending Co., New Haven, Conn., has developed a series of compact and highly accurate delay lines allowing broader band operation, lower attenuation, accuracy at higher frequencies and greater stability.

The delay lines, consisting of 285 feet of 1/2 inch, 50 ohm Foamflex cable in each unit, were produced by American Tube for the Emerson Research Laboratories, Inc., Division of Emerson Radio-Phonograph Corp., Silver Springs, Md. They will be utilized in missile check-out equipment.

The delay time within each line has tested accuracy of ± one millimicrosecon Terminating ends are bent on a two inc



radius. The size of each unit is 16 inche across (diameter) by six inches in heigh

Circle Reader Service Card 122

—*mwj*—

RAYTHEON INTRODUCES HIGHL SHOCK-RESISTANT RECTIFIER TUB

A highly shock-resistant rectifier tube ha been introduced by Raytheon Company Industrial Components Division, Newto Mass.

The 3B24WA, now available in quantit is a high-voltage type, designed for longe life and greater reliability than previou models. The hard-glass tube is tested an controlled according to Mil E-1/110. Th tube features a thoria-coated, direct-heatin filament and a "moly" anode, sprayed wit pure zirconium.

Circle Reader Service Card 123

—*mwj*—

LEL MODEL MMC-3 ANNOUNCED

LEL
LOW NOISE
MIXER-PREAMPLIFIER
MODEL MMC-3
FREQ. RANGE
4.0-8.0 KMC
INT. FREQ.
30 MC

The latest addition to the coaxial-mixe preamplifier series produced by LEL, Inc Copiague, N.Y., the MMC-3, provides low-noise coverage over the 4.0-8.0 km spectrum. Overall gain is 25 db minimum typical noise figure is 7.5 db, IF bandpas is eight mcs in either 30 or 60 mc cente frequency versions.

The MMC-3 supplements LEL's MML- and MMC-2 octave coverage coaxial mixe preamplifier units.

Circle Reader Service Card 124

—*mwj*—

NEW LINE OF COAXIAL WAVEMETERS ANNOUNCED BY WAVELINE

Waveline, Inc., Caldwell, N.J., an nounces a new line of transmission type coaxial wavemeters covering the frequency range from 2300 mc to 8200 mc. These units are equipped with oversized two inch micrometers directly readable to .0001

(*Continued on page 94*)

PRECISION—*Stainless Steel Waveguide* QUICK DISCONNECT

LOW COST
OFF SHELF DELIVERY
•
K BAND
X BAND
•
For Laboratory or Service Applications

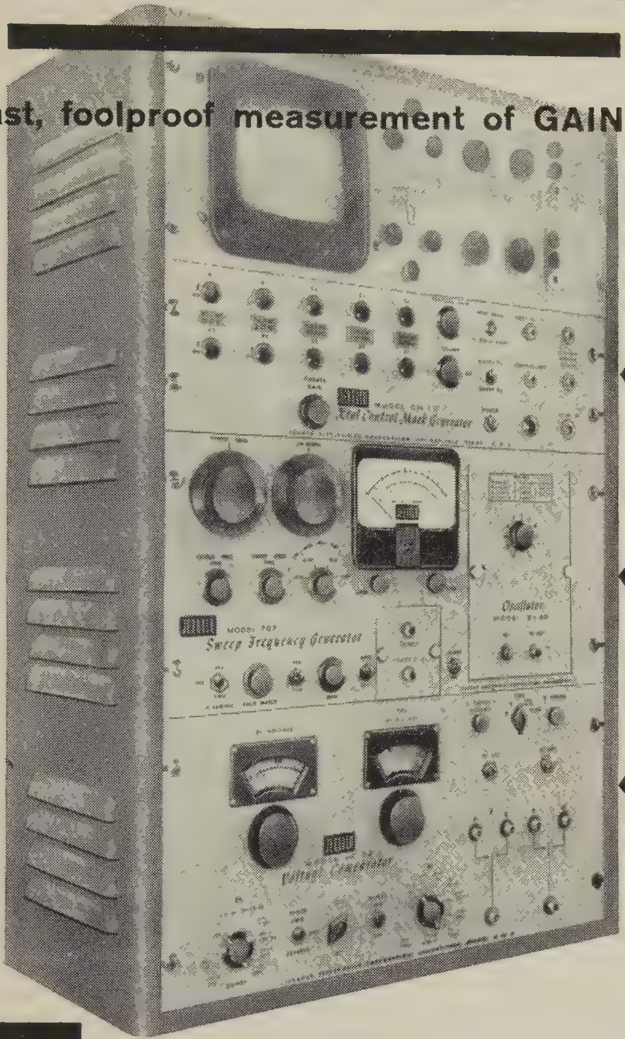
Direct Inquiries To James L. Tobin

AIRCRAFT ARMAMENTS, inc.
COCKEYSVILLE, MARYLAND

Circle Reader Service Card 50

AAInc
COCKEYSVILLE, MD.
MOD. 3419X
PAT. PEND.
INC.

BEST TEST SET YET!



For fast, foolproof measurement of GAIN, LOSS, VSWR, Q, X_L, X_c, Z

Crystal Controlled Marker Generator

Model CM-10—A 10-crystal unit producing any selected fundamental and/or harmonic frequencies. Each oscillator has its own independent amplitude control. Features built-in scope pre-amplifier and VSWR filter.

Precision Sweep Generator

Model 707—The heart of the test set. Features an extremely flat RF output (±5/100 db) and variable rate, all electronic sweep with plug-in oscillators available covering 2 to 265 mcs. Provisioned for use with an X-Y plotter.

Accurate Voltage Comparator

Model VC-12 — The unit that makes Measurement By Comparison possible. A 3-section instrument that contains regulated DC and RF voltage supplies and a wide band coaxial comparator for the simultaneous visual presentation of reference standards against which the test information is compared.

Model 1707 Price **$1,570.00**
(Oscilloscope, rack, or recorder not included)

JERROLD MODEL 1707

Complete RF TEST SET employs the **M**easurement **B**y **C**omparison technique

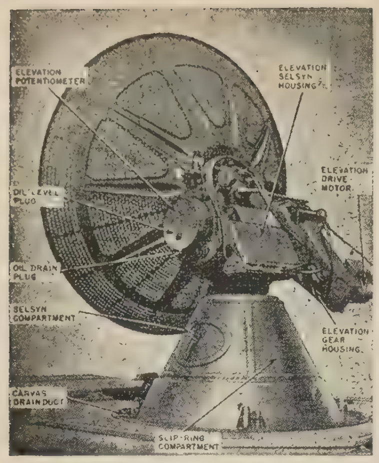
Interested in more than one frequency . . . an entire band, octave, or spectrum? Now it's no longer necessary to employ the slow, tedious, point-by-point method of measurement when working with a spectrum of frequencies. Jerrold's new 1707* test set will do the same measurement job *Faster*, more accurately, and with fool-proof results. Featuring the **M**easurement **B**y **C**omparison technique, the model 1707 provides a continuous visual presentation and self calibration against precision standard attenuators (and/or accurate DC and RF voltage sources referenced against a standard cell). So, whatever your laboratory, production, or field needs—Jerrold's sweep frequency **MBC** method will serve them better.

Write today for complete catalog and technical newsletter series on MBC procedures.

JERROLD **ELECTRONICS CORPORATION**
Industrial Products Division, Dept. ITE-78 Philadelphia 32, Pa.
Jerrold Electronics (Canada) Ltd., Toronto • Export Representative: Rocke International, N.Y. 16, N. Y.

*Similar test sets available for other ranges

Circle Reader Service Card 51



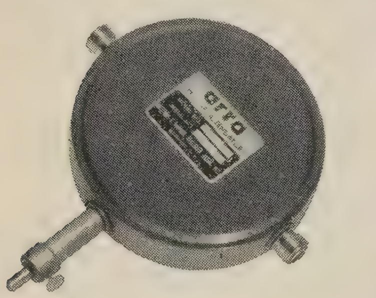
ANTENNA PEDESTAL
SCR 584—MP 61B

Full azimuth and elevation sweeps. 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ. 9 degrees per second squared EL.4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplidynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar systems, radio astronomy, any project requiring accurate response in elevation and azimuth.
Complete description in McGraw-Hill Radiation Laboratory Series, Volume 1, page 284 and page 209, and Volume 26, page 233.

RADIO RESEARCH INSTRUMENT CO.
550
FIFTH AVE.
NEW YORK
JUDSON
6-4691

Circle Reader Service Card 67

arra π LINE CONTINUOUSLY VARIABLE ATTENUATOR



Exclusive Features:

- Broadband Impedance Match.
- Min. VSWR for all values of attenuation over band.
- Insertion Loss: 0.2 db max.
- Drive: Shaft drives for systems & power level applications.
- Connectors: Type "N" Female (others on request).
- Size: 5" dia. x 1" high, excluding connectors and micrometer.
- Power Rating: 10 watts average min.
- Continuously variable for all values of attenuation.

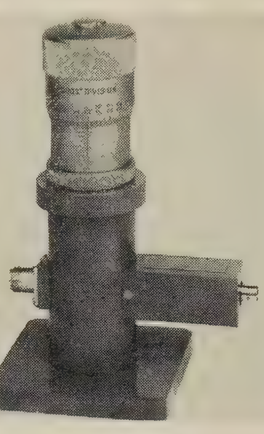
Write for Information — Dept. P-IRE

arra Antenna & Radome Research Associates
27 BOND STREET • WESTBURY, N. Y.

(*Continued from page 92*)

inches. The meters are calibrated every 50 mc.

The standard models are available with female type N input and output connectors or with a direct DC output through a female type BNC connector. The latter crystal output model numbers are suffixed with CR: these meters are adjusted to give a minimum of 20 microamperes DC output with one mw input power.

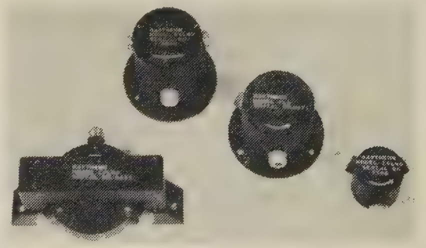


Waveline's model 950 crystal current indicator is an accessory for use with all wavemeter models. A 50 microamperes three inch square meter adds to the ease and precision with which the resonant frequency can be adjusted. The instrument is equipped with a female type BNC input connector and a variable sensitivity adjustment.

Circle Reader Service Card 125

—mwj—

MINIATURIZED THREE-PORT CIRCULATORS ANNOUNCED



A new line of miniaturized three-port circulators designed for operation in UHF, L and S-bands has been announced by Raytheon Co.'s Special Microwave Device Operations, Waltham, Mass.

The extremely low-loss, three-port models come in four basic designs covering the band from 800 to 4000 megacycles with operation over 10 per cent bandwidths in each range. Each provides less than .4 db insertion loss and minimum isolation of 20 db. VSWR on all units is 1.25 maximum.

The new coaxial circulators have increased performance over previous models despite a decrease in diameter of as much as five inches. A design feature of the L and S-band units makes it possible to mount them within external magnetic fields or close to ferrous metals without affecting operating characteristics. This feature allows greater flexibility in mounting the units in a compact system wit the usual separation that is required prevent degaussing.

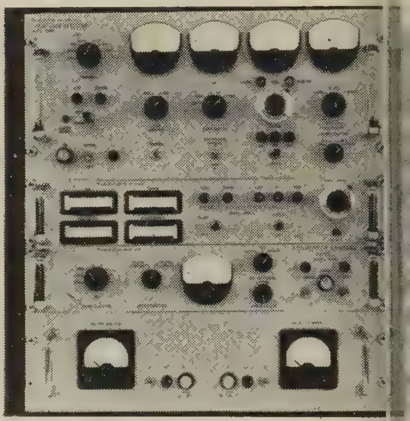
All models are provided with Type female connectors and are capable of ha ling peak power of five kw and aver power of five watts. Use of Type connectors on units in the 800 to 1 megacycles range makes possible hand capabilities of up to 100 kw.

Raytheon's new circulators have br operating temperature ranges with creases possible where a narrower ba width is required. Weight reductions previous models are significant — as m as a nine pound weight decrease in S-band model.

Circle Reader Service Card 12

—mwj—

NEW PHASE LOCK TELEMETR RECEIVER ANNOUNCED



The first of a new series of Phase L Receivers has been announced by Ha more Electronics Division, Siegler Co Anaheim, Calif.

The new receiver, designed to integ Hallamore phase lock detection with entire series of complementary modu operates with a wide dynamic range 100 db at a sensitivity of —185 dbw. five modules that constitute the recei are the Detector, Converter, Conve Control, Remote Acquisition Control, Power Supply.

The Detector unit, operating with a mc input, provides all controls for basic receiver, and the data outputs recording purposes.

Major factor in the overall versatility the receiver system is the Converter Converter Control modules. The Con ters, normally positioned at the ante site are available in models to cover 108, 135, 378, and 960 mc bands. Converter Control modules, located at receiver panel, are used for controll and monitoring the Converters. Ot modules, Remote Acquisition Control (tional) to provide tuning, sweep fu tions, and meter indication from a rem point, and power supply are par mounted units, also located at the recei

Circle Reader Service Card 127

—mwj—

(*Continued on page 96*)

TURES:

- new low in noise levels — down to 007 μv providing 0.02 μv full scale nsitivity at minimum bandwidth.
- db steps
- tenuation range of 85 db
- DUR regular VSWR scales plus one panded
- eter scales automatically normalized hen switching from regular to expanded
- arge 5¾″ meter with 1% linearity
- ontinuous gain control over 15 db nge
- ontinuously variable bandwidth control
- ront panel meter monitors bolometer as current

CIFICATIONS:

uency: 1,000 cps; adjustable over a % range.

itivity: 0.02 μv at minimum (4 cps) ndwidth. 0.1 μv at maximum (40 s) bandwidth.

e Level: 5db below full scale (0.007 at minimum bandwidth).

lifier Q: 250 at 4 cps; 25 at 40 cps.

dwidth: Continuously variable from 4 40 cps.

bration: Square Law. Meter reads WR, db.

ge: 85 db. Input attenuator provides 0 db in 5 db steps. Gain control prodes 15 db adjustable. Accuracy ±0.1 b per 10 db. Maximum cumulative rror of ±0.2 db at 40 cps bandwidth.

e Selector: Expanded, Regular, and olometer Current. Meter scale always ormalized when switching from xpanded to regular.

er Scales: SWR: 1-4; SWR: 1.8-6; WR: 3.2-10; SWR: 6-15; Expanded WR: 1-1.3; db: 0-10; Expanded db: -2.3.

ut Selector: 220,000 ohms; Crystal; olometer. Bias provided for 8.75 ma olometer or 4.3 ma bolometer. Bias djustable ±15%. A bolometer protecve circuit permits any switching operaon or cable connect-disconnect without amage to bolometer.

put: Jack for 1500 ohm recorder, 1 ma ll scale deflection.

ut Connector: BNC Jack.

ver: 115/230 v ±10%, 50-60 cps, 40 atts.

ensions: Cabinet: 7¾″ wide, 10½″ igh, 11″ deep.

ght: 14 lbs. net.

this standing wave amplifier defies comparison

VOLTAGE STANDING WAVE RATIO
DB
BANDWIDTH
INPUT SELECTOR
SWR DB
SCALE

The new portable PRD 277-B Standing Wave Amplifier is designed to meet the present and future needs of microwave test laboratories. Due to its extremely low inherent noise, 0.007 μv, weak signals which once were undetectable by conventional instruments can now be measured. Attenuation in 5 db steps combined with 4 VSWR scales and a large meter permit VSWR measurements to be made with maximum resolution and accuracy.

To find out more about the new PRD 277-B Standing Wave Amplifier, contact your local PRD representative or phone, write, or wire:

PRD ELECTRONICS INC.
A Subsidiary of Harris-Intertype Corporation
Formerly Polytechnic Research & Development Co., Inc.
Factory and General Office: 202 Tillary Street, Brooklyn 1, New York, ULster 2-6800
Western Sales Office: 1608 Centinela Ave., Inglewood, Calif. • ORegon 8-6922

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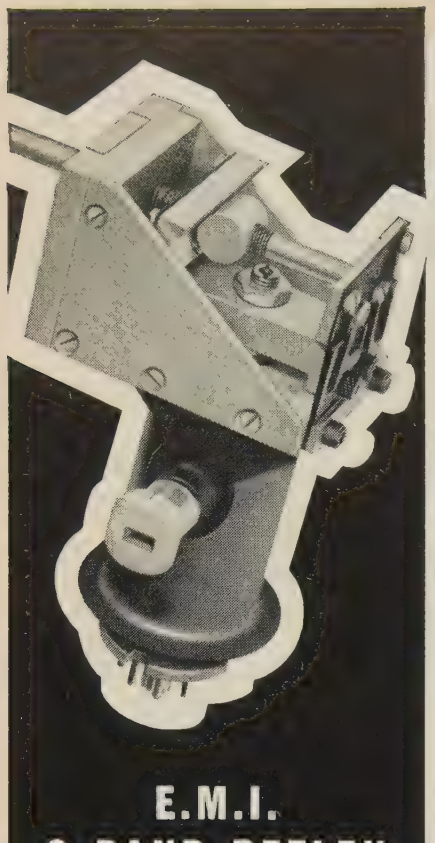

E.M.I.

Q-BAND REFLEX KLYSTRONS

Five high voltage, integral cavity types, with improved plate tuner for good frequency stability and freedom from microphony.

Type No.	Approx. f range KMc/s	Min. Power (mW)	I_A (mA) (at V_A=2KV)
R9521	35—40	15	12
R5146	34.2—35.6	30	10
R9546	32—38	15	12
R9518	28—32	15	12
R9547	24—28	15	12

Average electronic tuning range of above, 60 Mc/s; WG22 waveguide termination

...AND A NEW K-BAND KLYSTRON:

with similar external dimensions and tuner to R9546:

R9602 22—26 15

Average electronic tuning range, 40 Mc/s: WG20 waveguide termination.

The extensive range of EMI special tubes includes: plug-in klystrons & cavities, photomultipliers, camera & C.R. tubes.

EMI

E.M.I.
ELECTRONICS
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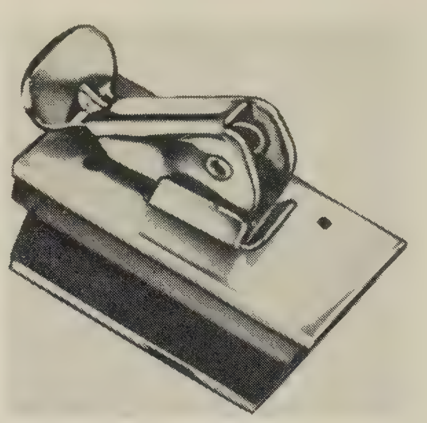
804 NEWBRIDGE AVE. WESTBURY L.I., N.Y. Tel: EDgewood 3-6650

New Products

(*Continued from page 94*)

RECTANGULAR 'SNAP-TITE' PLUG PRODUCED



A new fast-opening and closing rectangular plug designed for pressure-testing microwave waveguides is now being produced for the electronics and communications industries by Moeller Mfg. Co., Racine, Wisconsin.

This new plug provides an airtight seal for the ends of sections of waveguides, and may be put in place or removed quickly and easily during pressure testing operations. The rubber plug is expanded inside the waveguide simply by pressing a small lever on the top of the plug. Releasing the plug is accomplished by lifting the lever. Service life of plugs is virtually unlimited.

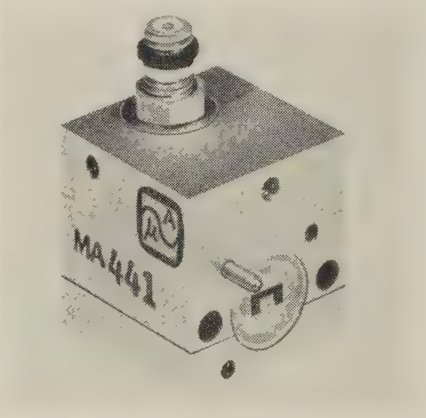
Marketed under the trade name "Snap-Tite," these plugs are available in a wide range of sizes and shapes.

Circle Reader Service Card 128

—*mwj*—

BROADBAND VIDEO DETECTOR AVAILABLE

Microwave Associates, Inc., Burlington, Mass., announces availability of a new broadband video detector for high tangential sensitivity receiver use over the 40-75 kmc frequency range.



Minimum tangential signal sensitivity over the entire frequency range is —27 dbm for a receiver bandwidth of 2.5 megacycles and 100 kc low frequency cut-off. Smooth response without resonance power drop out ripples is achieved over the entire frequency range. The MA-441 features a rugged construction suitable for airborne applications. A mica window recessed in the detector waveguide in prevents entry of dust, dirt, moisture,

No external holder is required. Wa guide connection is provided for adaptat to ridged RG-98/U or to a taper appro ate for standard RG-97/U (MA-803) RG-98/U (MA-512) waveguide. diode and whisker are mounted acros section of ridged RG-98/U waveguide best broadband response. All electr conducting surfaces are silver pla throughout.

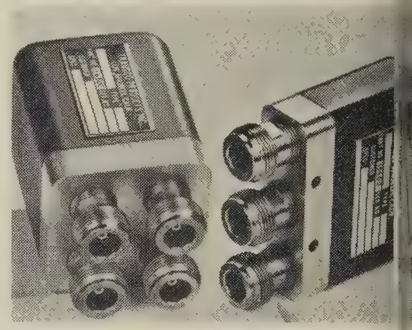
Circle Reader Service Card 12

—*mwj*—

NEW MINIATURE COAXIAL SWITCH LINE INTRODUCED

A new line of type W miniature coa switches has just been developed by Tr co Products, Inc., Los Angeles, Cal.

The new line includes SPDT and Tr fer switches which are available with ei Type N or TNC connectors. Each uses 28 VDC solenoids. The SPDT latching type that requires no hol power. The double throw transfer has one solenoid and switches from set of contacts to the other when e gized. Typical RF characteristics at kmc are 1.15 VSWR, .2 db insertion l and 50 db crosstalk.



The SPDT switch is 3/4 inch x 2 inches x 2 1/2 inches, 5.5 oz. and Transfer switch is 1 3/4 inches x 1 inches x 3 1/4 inches, 10 oz.

Circle Reader Service Card 13

—*mwj*—

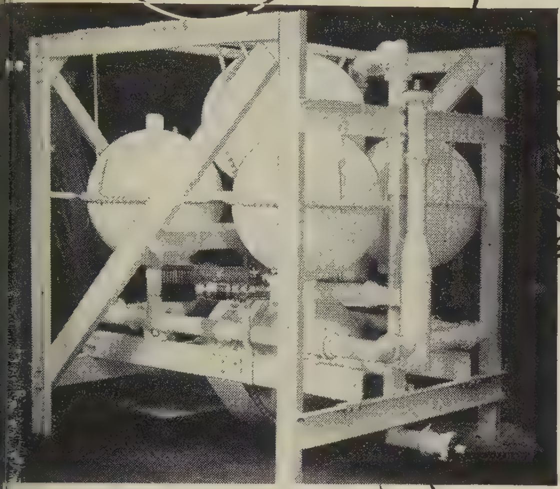
MICROWAVE RELAY LINK ANNOUNCED BY ELECTRONI SYSTEMS

Electronic Systems, a Division of chanical Products, Inc., Jackson, Mi announces a new low cost microwave r link with a baseband width of five power output of 0.1 watt, and opera in the 10,500 to 13,200 megacycle ra for point-to-point FM transmission television signals, one way voice c munications channels and data channe

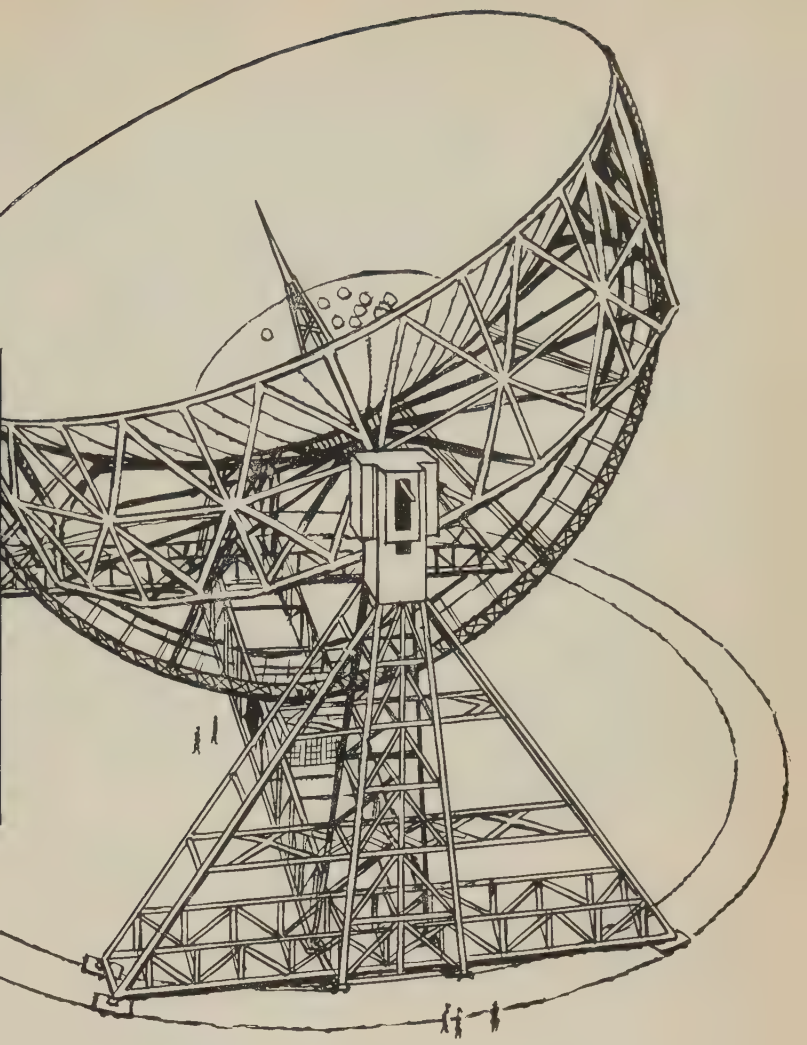
The small size, portability and low ($4,490.00 for the complete system) dicate its use in linking scattered offi permitting the economical transmission closed circuit television pictures, com ter data, remote control functions and t

(*Continued on page 98*)

ANOTHER MEASURE OF DIELECTRIC'S CAPABILITY



THIS UHF DIPLEXER NETWORK was built by **DIELECTRIC** Products Engineering Company, Inc., under contract from Space Technology Laboratories, Inc. It is now installed in the tower of the single giant antenna of "SpaN Net's" Jodrell nk radio telescope at Manchester, England. Its function is



olating simultaneous signals to and from deep-space payloads

Commanding and monitoring space vehicles is the responsibility of "SpaN Net" . . . a global network of radio telescopes set up and operated by Space Technology Laboratories for U.S.A.F.

To fulfill its mission, "SpaN Net" had to meet challenges far beyond the state of the communications art. Never before had powerful command signals and faint telemetered deep-space data been simultaneously handled by a single antenna. How could transmit and receive channels with a differential of more than 200 decibels be isolated? Conventional diplexer technology was not the answer.

Teamwork solved the isolation problem! "SpaN Net" assigned the task to Space Technology Laboratories, Inc., who added DIELECTRIC of Maine to its research, development and production team. Result? An ultra-high-frequency diplexer network that allows the Jodrell Bank radio telescope's single antenna to transmit 20 kw commands and receive 0.002 microvolt signals . . . simultaneously.

This contribution to SpaN Net's break-through is typical of product advances by DIELECTRIC. If you have similar problems in communications . . . from design to delivery . . . it pays to contact DIELECTRIC. Capabilities, facilities and accomplishments are described in our brochure. Write for it today.

Other areas of **DIELECTRIC** capability in coaxial, waveguide and open wire techniques . .

TRANSMISSION LINE & COMPONENTS • NETWORKS • SWITCHES • ANTENNAS & FEEDS
TEST EQUIPMENT • R&D ENGINEERING

ial DIELECTRIC
for solutions to
communications
problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

Circle Reader Service Card 55

Shrinking the Universe...

through Communications

BY APPLYING TOMORROW'S CONCEPTS TODAY...
AT AMHERST LABORATORIES

today's dynamic R & D mission also includes creative opportunities in Navigation, Microwave Data Handling, ECM and Radar Systems

Man's vision of future exploration in the infinity of outer space is predicated on pertinent data that can be gathered by each space probe today. As the probe distances increase... our universe becomes smaller and communications are the vital link that proves success or failure of each venture into the unknown. It is imperative that new systems of communications be developed well in advance of other facets of space technology. At Amherst Laboratories new solutions are sought to communications problems even before they are encountered. Creative ideation is not compromised by conventionally accepted conclusions. Amherst Laboratories is currently anticipating tomorrow's electronics needs in areas of advanced Ground, Air and Space Communication.

PROFESSIONAL STAFF AND MANAGEMENT OPPORTUNITIES *are unlimited for Electronics Engineers, Physicists and Mathematicians with advanced degrees and creative desire.*

You are invited to direct inquiries in confidence to Mr. W. Serniuk, Director, Amherst Laboratories... or call NF 3-8315 for information. All inquiries will be acknowledged promptly.

SYLVANIA ELECTRONIC SYSTEMS
A Division of SYLVANIA
Subsidiary of GENERAL TELEPHONE & ELECTRONICS
1182 Wehrle Drive, Williamsville, New York

AMHERST
LABORATORIES

New Products

(*Continued from page 96*)

metering information as well as its ge eral use in the communications indust proper.

The Transmitter and Receiver for th new link are each self-contained in ind vidual units weighing 31 and 32 lbs. r spectively with no need for separate co trol units or power supply. The 420 System is portable and may be mounte on tripod, pedestal or other suitable ba and includes both Transmitter and R ceiver in Portable Carrying Cases, a Va able Cavity Wavemeter for use with bo Transmitter and Receiver and two Pow Cables. The 420A rack-mounted version identical to the 420A except for subst tution of a rack mounting assembly f the portable cases.

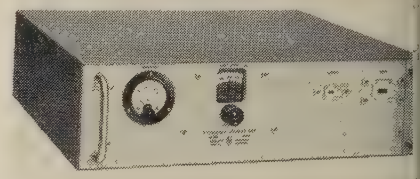
In the 420A System the parabola mou is self-contained on the case, eliminati any need for an additional mounting rin Cases are completely weatherproofed ar entire chassis is removable without remo ing parabola or case positioning.

Both units incorporate identical "ru gedized" Eimac klystrons for operatic under adverse conditions; low power co sumption (Transmitter-70w., Receive 160w.); Plug-in I. F. Amplifier for ea replacement or servicing; all controls a cessible from front panel; calibrated va able frequency Wavemeter allows chan in operating frequency without need f Wavemeter replacement; a built-in te meter for all tuning and voltage measur ments; built-in input signal attenuator; full 5 mc. bandwidth, flat within .5 db.; modulator test output connector for tes ing conveniences; and reliable AFC actic with pull-in range over the entire I. bandpass.

Circle Reader Service Card 131

— mwj —

NEW FREQUENCY DOUBLER AVAILABLE

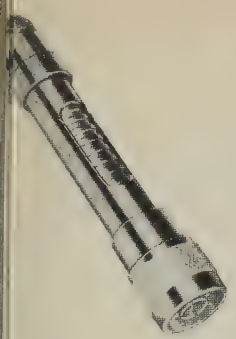


Two frequency doubler sets which co veniently provide low cost signal gener tion capability up to 40 kmc are no available from Hewlett-Packard Co., Pa Alto, Cal.

The new doubler sets, Models 938 and 940A, operate on a harmonic gener tion principle and may be driven by kl strons, sweep oscillators or by sign generators such as the Hewlett-Packa 626A or 628A.

Model 938A supplies power from 1 to 26.5 kmc when driven by a 9 to 13. kmc source; Model 940A supplies pow from 26.5 to 40 kmc when driven by 13.25 to 20 kmc source. Both mode contain a power monitor and a precisi

(*Continued on page 100*)

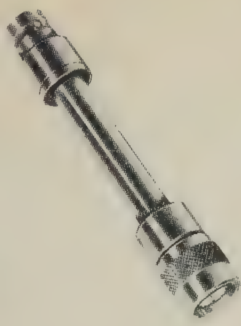


ABLE LV SERIES

e continuously variable, low s filters permit infinite ation of cut-off frequency in their range (200-4000 Sliding adjustment permits ing of cut-off frequency im- iately above the operating uency to provide maximum nonic rejection; with a pass d null on the exact operating uency, the optimum in pass d characteristics can be eved.

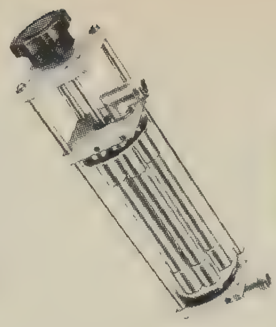
LOW PASS LA, LB, LC SERIES

These low pass filters exhibit an extremely broad stop band with no spurious response at frequencies less than 6 times cut-off. The pass band attenuation and VSWR are very low with excellent cut-off characteristics. Available in medium and high power; miniaturized for airborne applications.



HIGH PASS HA, HC SERIES

These high pass filters provide low attenuation and VSWR over a broad pass band. The stop band attenuation rises sharply at cut-off and has no spurious responses. The HA series is available in medium power ranges. The HC is miniaturized for airborne applications.



TURRET LT SERIES

Six low pass filters are mounted around a central shaft and selectively engaged by a coaxial switch. Each filter has a cut-off frequency approximately 1.6 times the next lower frequency filter. The turrets provide a total bandwidth of over 10 to 1 in which any fundamental frequency can be filtered with a minimum of 20 db on the second harmonic and 60 db on any third through sixth harmonic.

IGH & LOW PASS COAXIAL FILTERS FROM 100 TO 10,000 mc

Microlab manufactures a complete line of medium power, high power and miniaturized low pass filters; turret and continuously variable low pass filters; — medium power and miniaturized high pass filters. Units are available from stock for immediate delivery in the 5 standard Microlab connectors (Types N, BNC, TNC, C, HN) and in as many as 15 standard frequencies. Other frequencies and connector combinations are available for delivery within 2 weeks.

GENERAL SPECIFICATIONS

Microlab Series	LA	LB	LC	HC	HA	LV	LT
Cut-off Frequency (F_C)	200-10,000 mc	200-2,000 mc	100-1,000 mc	100-1,000 mc	200-8,000 mc	200-4,000 mc	200-10,000 mc
Max. Pass Band VSWR	1.30	1.30	1.50	1.80	1.80		1.6
Max. Pass Band Insertion Loss	0.2 db	0.2 db	0.4 db	0.8 db	0.5 db	0.3 db	0.5 db
Insertion Loss (1)	25 db	25 db	15 db	21 db	28 db	20 db	
Min. Stop Band Insertion Loss (2)	60 db	60 db	40 db	60 db	60 db	50 db	40 db
Impedance	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
Power Rating (Average)	10 watts	500 watts	10 watts	10 watts	50 watts	15 watts	10 watts
Power Rating (Peak)	4 kw	10 kw	1 kw	1 kw	2 kw	1 kw	2 kw
Temperature Range	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C
Environmental	Mil-E-5272	Mil-E-5272	Mil-E-5272	MIL-E-5272	Mil-E-5252		
Finish	Silver Plate	Silver Plate	Silver Plate	Silver Plate	Silver Plate	Silver Plate	

Notes: (1) 1.2 Fc for low pass. 0.8 Fc for high pass (2) 1.5 to 6.0 Fc for low pass. Dc to 0.5 Fc for high pass

MICROLAB

570
W. Mt. Pleasant
Avenue
Livingston, N. J.
WYman 2-5700

Circle Reader Service Card 57

(*Continued from page 98*)

100 db attenuator for accurate power setting.

Output power of the doubler sets is typically 0.5 to 1 milliwatt when driven by the -hp- 626A or 628A signal generators. Input power is 10 milliwatts (design center) and 200 milliwatts (maximum). Output monitor accuracy is ± one db to ± two db depending upon the model and frequency. Output attenuator accuracy of the doubler sets is ± two per cent of reading or 0.2 db, whichever is greater. Attenuator range is 100 db.

The Model 938A and 940A frequency doubler sets are priced at $1,500 each. Current availability is 12 weeks.

Circle Reader Service Card 132

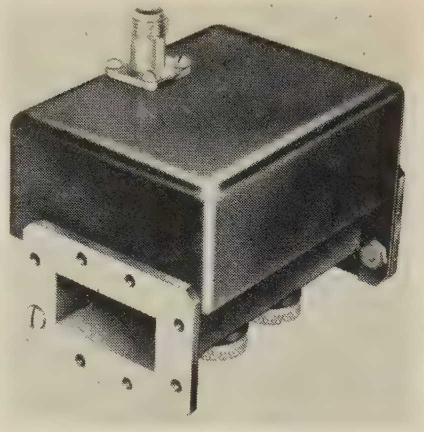
—*mwj*—

NEW ULTRA HIGH-SPEED SWITCH ON MARKET

A new ultra high-speed microwave switch is now being marketed by Kearfott Microwave Division, General Precision Inc., Van Nuys, Cal., manufacturers of precision microwave components and test equipment.

This new switch consists of three identical switching cells — each capable of 17 db isolation and 1.5 db insertion loss. The three cells cascaded together into this new unit offer 40 db of isolation and 4.8 db maximum insertion loss. Similar characteristics may be obtained at X and KU band frequencies using the correct number of cells to give the necessary isolation.

Features include: Switching speed: Rise time: 10 millimicroseconds max.; Decay time: 10 millimicroseconds max.; Frequency Band: 5.4 to 5.9 kmc; Isolation: 40 db min.; Insertion Loss: 4.8 db max.; Power Handling: 40 milliwatts; Drive Power Required: 150 milliwatts; Length: four inches.



Circle Reader Service Card 133

—*mwj*—

ALL SOLID STATE UHF POWER SOURCE AVAILABLE

The Special Products Operations of Philco's Lansdale, Pa. Division has announced the first commercially available all solid state microwave generator. The new UHF power source has been designed to deliver a minimum of five mw available power at 2.2 Gc.

When compared to conventional, nc solid state power generating devices f UHF frequencies, the new Philco sol state power source offers an efficiency i provement of up to two orders of mag tude.

Only four semiconductor components all products of the Philco-Lansdale Di sion — are utilized in the generator. T first two stages include a "field-flov transistor oscillator and a "field-flov power amplifier. Two harmonic conve sion stages, each utilizing a varactor a employed to take the amplified 116 r transistor output to 2.2 Gc.

Delivery of Philco's solid state UH generator is available within 90 days at unit price of $2,465.

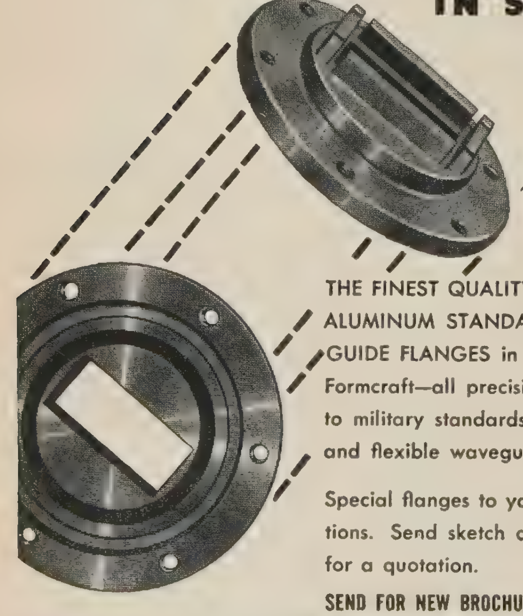
Circle Reader Service Card 134

—*mwj*—

NEW MINIATURE "C" BAND OSCILLATOR PRODUCED

The newest member of the Gombos li of oscillators is the Model 151C Mini ture Triode Oscillator with a power ou put 65 milliwatts minimum at 4200 M designed and produced by the John Gor bos Co., Inc., Clifton, N.J.

Only 4 1/2 ounces in weight, th Miniature "C" Band Triode Oscillat covers the range of frequencies from 42(Mc to 6000 Mc in 50 Mc minimum step Each oscillator is designed for maximu stability having temperature stability



ALL SIZES

M S FLANGES

IN STOCK

THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

SEND FOR NEW BROCHURE #14B DESCRIBING AND ILLUSTRATING ALL THE STOCK FLANGES

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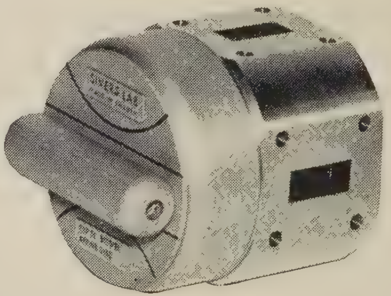


WAVEGUIDE-SWITCHES

HIGH POWER
LOW VSWR
LOW CROSS TALK
PRESSURIZED
RUGGEDIZED
FAST SWITCHING

SIVERS LAB Manual Waveguide Switches are an ideal solution to the problem of quick and economical testing of both high and low power microwave systems. The automatical types have been designed for use in microwave systems, where *very fast* switching is required.

Both automatical and manual types are manufactured for frequencies from 1100-18000 Mc/s. Because of their very low VSWR, for some types below 1,03, and their low cross talk better than 80 dB the switches are also very suitable for laboratory use to speed up tests of microwave tubes, components, etc.

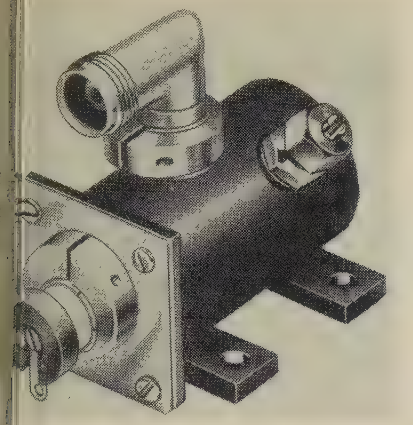
SIVERS LAB manufactures high precision microwave instruments and components for modern radar- and radio-links.

Please write for our complete catalogue.

SIVERS LAB
Box 42018
Stockholm 42
Sweden
Elektravägen 53
Phone: 18 03 50
Cable: Siverslab

Circle Reader Service Card 37

kc per degree C, minimum size, mum output and has a vernier (50 control of frequency. Only a plate ge of 200v nominal and 6.3v for



nents are required, thus simplifying er problems.

he 151C also features pre-set tuning. s tiny unit may be applied as a local llator, CW signal source and driver crystal harmonic generators.

Circle Reader Service Card 135

— mwj —

W SQUAREWAVER AVAILABLE FROM MELABS

A new squarewaver which is used to uare wave modulate RF power in the to four kmc range is now available m Melabs, Inc., Palo Alto, Cal.

The squarewaver, Model X-143, con- ns a battery-operated transistorized mul- ibrator which drives a solid state chop- r. This method provides square wave dulation for klystrons and signal gener- rs which is completely F.M. free.

The modulation frequency of Model 143 may be varied from 800 to 1200 s with a convenient control knob. Over- dimensions of the new squarewaver, in- ding controls and connectors, are 3-1/2 ches x two inches x two inches. Delivery 30 to 45 days for limited quantities.

Circle Reader Service Card 136

— mwj —

BENDIX DEVELOPS TINY OSCILLATOR

A subminiature transistorized subcar- r oscillator has been developed by the cific division of The Bendix Corp. for e in advanced telemetering systems to ck the performance of missiles, air- anes and space vehicles.

The oscillator, designated the TOE-300, is a radio frequency generator only 1 1/2 cubic inches in size. It maintains the efficiency and reliability of earlier, larger models which occupied several times as much space in telemetering equipment, according to Bendix-Pacific.

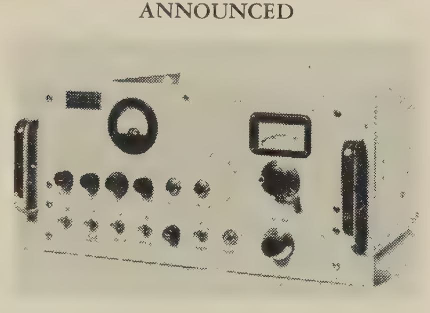
The unit is claimed by the company to have an exceptionally long lifespan under severe environmental conditions — such as shock, vibration and temperatures — in space vehicles.

Telemetering equipment measures, transmits and records data automatically on the performance of systems ranging from oil pipeline networks to rockets.

Circle Reader Service Card 137

— mwj —

SPECIAL PURPOSE RECEIVER ANNOUNCED



A new Special Purpose Receiver for AM and CW reception is announced by Nems-Clarke Company, Division of Vitro Corp. of America, Silver Springs, Md., having a tuning range of 55 to 260 megacycles. It is specifically designed for measuring the Doppler shifts of incoming signals and features a low noise figure with uniform performance throughout the entire range.

The receiver has provision for comparing the received input signal with a standard reference signal of known characteristics, the amplitude of which is offset by an amount slightly greater than the maximum Doppler shift expected. The output is the difference between the incoming signals.

The receiver is 19 inches wide, 8-3/4 inches high and 15 inches deep designed for mounting into a standard 19 inch instrument rack; it weighs 36 lbs. and is finished in gray enamel. Operating power requirements: 117 v, 60 cps, AC, 70 watts. Price $1980.00.

Circle Reader Service Card 138

— mwj —

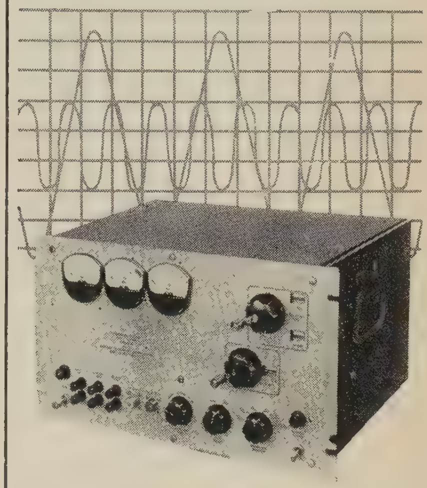
TRIDEA ANNOUNCES NEW LOW-COST IF AMPLIFIER

A new, low-cost, general purpose IF amplifier for radar receiver or instrumentation is announced by Tridea Electronics of South Pasadena, Cal. The Model 10A amplifier incorporates only MIL approved components and is fully compliant with FAA R-777.

New design incorporates a low-noise cascode input circuit utilizing the 417A triode, double-tuned interstage coupling for maximum gain-bandwidth, excellent skirt selectivity, and a low-impedance cathode-follower output.

(*Continued on page 102*)

WIDE RANGE POWER OSCILLATOR



a reliable signal source for microwave measurement

The AIL Type 124C Power Oscillator is applicable as a signal source over the wide range of 200 to 2500 Mc. Its range, power and stability make it an essential element of microwave component test systems. It is often used in measurements relating to antenna design. Facilities for both internal and external modulation are provided. Relative power output is indicated directly on panel meter.

Detailed literature is available on request.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, N. Y.
A DIVISION OF CUTLER-HAMMER, INC.

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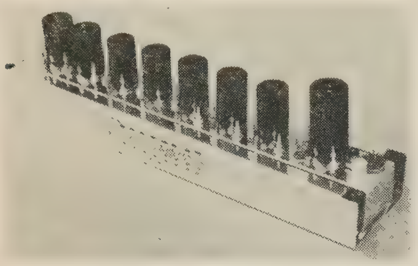
(*Continued from page 101*)

Typical characteristics are: noise figure 1.75 db, 60 mc center frequency, 10 mc — 3 db bandwidth, 20 mc — 40 db bandwidth, 70 db gain control range.



Special designs can be engineered by Tridea's engineering staff to meet desired performance specifications. Designs for balanced mixer input, specialized AGC and IAGC, Fast Time Constant, and other circuitry are available to meet specialized applications.

Circle Reader Service Card 139

— *mwj* —

NEW TUNNEL-DIODE OSCILLATOR DEVELOPED

A new device in the electronics field — the solid-state tunnel diode — has been adapted for producing microwave signals in a new, tunable tunnel-diode oscillator developed by engineers of the RCA Electron Tube Division, New York, N.Y., it was announced recently.

"This new solid-state oscillator," said H. K. Jenny, Manager, Engineering, Microwave Tube Operations, "is the first device outside the computer field to make practical use of the tunnel diode, a semiconductor device no larger than a small pill. This diode is combined with a microwave circuit to provide a new type of tunable signal-source component that can be designed to meet the myriad needs of new radar, telemetry, and satellite systems."

The new device, now available on a sampling basis, was developed by C. L. Cuccia, Engineering Leader, Microwave Solid-State Systems, and Reynold Steinhoff, Microwave Engineer.

The oscillator, designated the RCA Developmental Type SS-100, is a package approximately six by three by 5/8 inches in size, exclusive of tuning dial and connectors, and less than one pound in weight. Application of only 0.2 volt to the oscillator unit produce a power output of several tenths of a milliwatt, tunable over the 100-1400-megacycle band.

Circle Reader Service Card 140

— *mwj* —

NEW EXHAUST STATION AVAILABLE

Bon-De Electronic Laboratories, Inc., Beverly, Mass., announces the availability of a new four in one exhaust station. This pumping system will allow a tube manufacturer to use one vacuum system to perform a variety of jobs.

This pumping Station consists basically of a four inch diffusion pump, wal cooled baffle, charcoal trap and four i main line gate valve. The diffusion pu is backed by a five cfm mechanical pur One inch bellow-type valves are loca on the diffusion and roughing lines, a stainless steel oven with an electrica

operated hoist provides a variety of c trolled temperatures for tube bake-c Electrical circuits include a 10 or 25 v filament supply for tube breakdown anc Bon-De Model BD31 Thermocour Bayard Alpert Gauge Control.

This system can be provided with f different manifold assemblies, any which can be easily connected to the s tem's port flange: gas tube manifo vacuum tube manifold, vacuum fir manifold with four Vycor Bell Jars, a VAC-ION table with a five liter VA ION pump.

The system is capable of produci pressures in the range of 10^{-8} mm I Delivery is in the order of 4-6 weeks.

Circle Reader Service Card 141

— *mwj* —

TURBO ANNOUNCES HALF-X BROADBAND TERMINATION

As an addition to its Half-X Comp nent, Turbo Machine Co., Lansdale, P announces a broadband termination f 0.900 by 0.200 inch ID waveguide. Th absorbing load exhibits a VSWR of le than 1.03:1 from 8.2 to 12.4 kmc.

Maximum power dissipation is one w average making the termination suitab for most low power design measuremer and production testing. Measuring s inches in length, cast aluminum constru tion results in a rugged yet light devic Flanging consists of a centered UG-67/ configuration.

Circle Reader Service Card 142

— *mwj* —

AMCI
LINE
STRETCHERS
CONSTANT
IMPEDANCE
Z₀ = 50 ohms

- ***Rated at 0.5 kw cw at 1000 mc*** except as limited by connectors; constant impedance with low SWR.
- ***Rugged and dependable;*** electrically active portions are enclosed in and protected by an external case.
- ***Intended for long service;*** sliding contacts are made between solid coin silver tubes and solid sterling-silver fingers.
- ***Provided with a locking device*** and with positive stops at both ends of the line-stretcher travel.

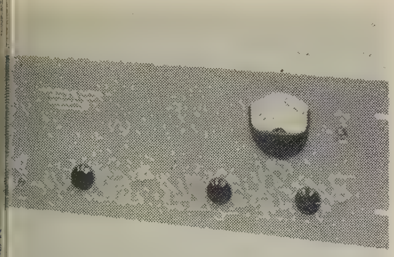
TYPE 3701B: 8" extension
TYPE 3702B: 14" extension
available with connectors to ⅞" EIA line, and Types N, HN or LC line.

Write for complete information on AMCI Line Stretchers

AMCI
ANTENNA SYSTEMS · COMPONENTS · AIR NAVIGATION AIDS · INSTRUMENTS
ALFORD *Manufacturing Company*
299 ATLANTIC AVE., BOSTON, MASS.

Circle Reader Service Card 60

HERMES COMPRESSED GAIN AMPLIFIER INTRODUCED



A new Compressed Gain Amplifier, del 110, which converts input voltage iation into decibel variations has n introduced by Hermes Electronics ., Cambridge, Mass. Operating over frequency range from 10 kc to mc the Model 110 Amplifier has a vir- lly linear transfer characteristic. It is d to measure the attenuation perfor- nce of crystal filters, tuned amplifiers, other frequency selective devices.

A simple front panel control permits ection of either 60 db or 80 db com- ssion. D-C voltage output from the plifier allows easy connection to an illoscope or vacuum tube voltmeter to mit measurement and display of voltage frequency characteristics of devices hav- an extremely large dynamic range.

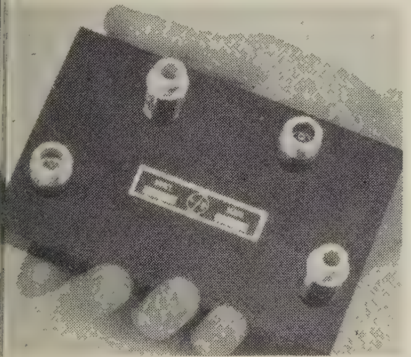
Other features include a front panel rload indicator and a high input im- ance of 500,000 ohms.

The Model 110 panel size is seven inches 19 inches. It mounts in a standard EMTA 19 inch rack. A four-prong nes plug (P404 AB) Power Input Con- ctor is located on the rear panel.

Circle Reader Service Card 143

—*mwj*—

LFE SHOWS NEW EPSI-LINE MICROWAVE COMPONENTS



A size reduction from normal waveguide mponents of approximately 20 to 1 is ossible with a new series of Epsi-line icrowave components developed by aboratory For Electronics, Inc., Boston, ass.

Designed to operate under adverse en- ronmental conditions, Epsi-line offers an dvantage over normal microwave plumb- g wherever size and weight is a factor. typical LFE Epsi-line measures 5-1/4 ches long by 3-1/2 inches wide by 9/16 ch thick and weighs about one pound. Epsi-line Broadband Balanced Mixers, for applications ranging from microwave instruments to radar and radio telescopy, are available from 0.8 kmc to 12.5 kmc.

Average specifications (bandwidth versus nominal 33 per cent band coverage without dc return) include: local oscillator and signal input impedance of 50 ohms; local oscillator and signal input VSWR less than 2 to 1; isolation of 20 db minimum between local oscillator and R.F. inputs; and, a noise figure eight db, ± 0.5 db, with nominal crystal current and local oscillator input power.

In addition to Mixers, LFE's Epsi-line components include directional couplers and multi-terminal power dividers for UHF and SHF applications. All units are hermetically sealed to withstand humidity, temperature, pressure, shock and vibration. All parts are encapsulated to allow no opportunity for movement. Catalog units in all three Epsi-line categories are available on two to four week delivery at $375 each.

Circle Reader Service Card 144

—*mwj*—

PARAMETRIC AMPLIFIERS AVAILABLE

Availability of custom-designed, reactance diode parametric amplifiers for applications at all microwave frequencies has been announced by H. J. Wissemann, general manager of the Apparatus division of Texas Instruments, Inc., Dallas, Tex.

"Simultaneous TI research programs on materials, device development and circuits have produced outstanding gain, bandwidth, and noise figures in amplifiers ranging from L through K_u bands," Mr. Wissemann said. "These devices now make it possible to obtain lower noise figures and subsequently greater range in radar, telemetry, communications and a host of other electronic systems."

The heart of TI's new parametric amplifier line is the gallium arsenide, variable reactance (varactor) diode (produced by TI's Semiconductor-Components division) which gives enhanced noise performance over a wide range of temperatures down to liquid nitrogen temperature (77°K).

Amplifiers available from TI include up-converters, and non-degenerate and degenerate negative resistance amplifiers. Any of these may have certain advantages which make it best for a given application, and TI advises that it can provide the assistance necessary to determine the type amplifier, noise figure, gain and bandwidth needed for a given requirement.

Circle Reader Service Card 71

—*mwj*—

(*Continued on page 104*)

New TRAK Type 2959,
1.5 KMc, tuneable
±50 Mc
TRAK
Div. of C & S Labs. Inc. Wilton, Connecticut
1
2

7

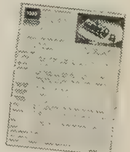
NEW Miniature
MICROWAVE
OSCILLATOR
CAVITIES
now available

TRAK Electronics Company, Wilton, Connecticut, announces the formation of TRAK MICROWAVE CORPORATION to increase its developmental facilities for triode cavities in r-f signal generation from 500 Mc upwards. Present low, medium and high power cavities are available for application in grid pulse, plate pulse, and CW service.

TRAK expanded its Microwave Cavity line, which started in 1949, by adding the following 7 NEW miniature Cavities in 1960:

TRAK Type 9127-L	At 1090 Mc, tuneable ±25 Mc, available from 900—1200 Mc.
TRAK Type 2958	At 925 Mc, tuneable ±50 Mc, available from 500—2200 Mc.
TRAK Type 2959	At 1.5 KMc, tuneable ±50 Mc, available from 500—2200 Mc.
TRAK Type 9127-SL	At 2 KMc, tuneable ±100 Mc, available from 800—7000 Mc.
TRAK Type 9127-S	Available in 3 segments of S-Band: 2700—3000 Mc, 3000—3300 Mc, 3300—3600 Mc.
TRAK Type C-3136	Tuneable 2700—3400 Mc.
TRAK Type 9127-C	Tuneable 5400—5900 Mc.

ALSO, OSCILLATORS ENGINEERED to your specifications!



We invite you to write for **new** TRAK MICROWAVE CAVITY BULLETIN.

TRAK
Microwave

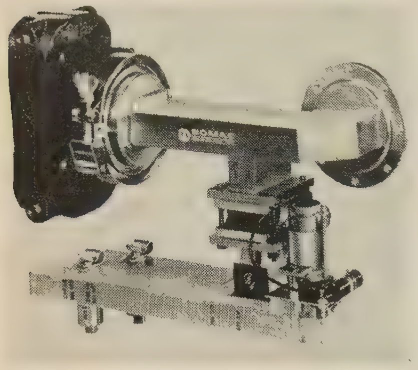
TRAK MICROWAVE CORPORATION
Subsidiary of
TRAK Electronics Company
5006 N. Coolidge Avenue
Tampa 3, Florida
REdwood 6-6422

Circle Reader Service Card 61

New Products

(*Continued from page 103*)

PRE-TESTED, PRE-PACKAGED MICROWAVE COMPONENTS EMPHASIZED BY BOMAC



Bomac Laboratories, Inc., Beverly, Mass. is now placing added emphasis on pre-packaged, pre-tested microwave assemblies, complete with components and associated hardware, ready for installation in a radar unit.

Typical is a "package" consisting of a branch guide duplexer and a balanced mixer, with magnetron, tunable TR tube, klystron and crystals.

Bomac engineers will design on order the modulator for this typical unit or other RF package to supply negative pulses for the magnetron, either as part of the same package or separately.

Circle Reader Service Card 72

E & M UNVEILS SMALL ISOLATOR

E & M Laboratories of Van Nuys, Cal., recently unveiled a small isolator commercially available for "X" band applications. The overall length of this new isolator is only 1/2-inch.

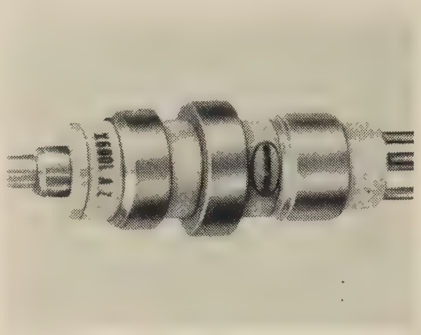
Performance figures guarantee a minimum isolation of 20 db and a maximum insertion loss of 0.3 db at 9375 ± 25 mc. The center frequency can be varied to meet customer requirements.

Circle Reader Service Card 73

—*mwj*—

THREE ADDITIONS TO REFLEX KLYSTRON LINE MADE

Three new reflex klystrons have been added to Polarad's family of rugged, wide tuning range ceramic Velocitron tubes. These new tube types ZV 1010X, ZV 1021X, and ZV 1009X operate from 950 to 2,800 mc, 1,000 to 4,000 mc, and 1,700 to 5,000 mc, respectively.



The power output of each of these tubes is 200 mw minimum. Up to 800 mw be obtained if a smaller frequency range used. They can be operated cw, puls and FM. The all ceramic and metal c struction achieves maximum shock a vibration resistance and non-micropho electrical characteristics. This construct allows the tubes to be operated with external cooling up to 500°F temperatu These tubes can be used as direct repla ments for existing low power reflex k strons.

Circle Reader Service Card 74

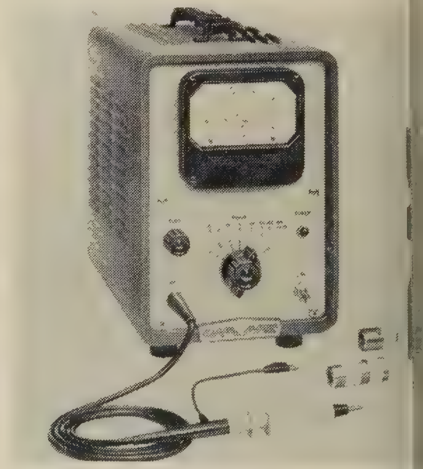
—*mwj*—

NEW MILLIVOLTMETER MEASUR RF VOLTAGES

A new RF millivoltmeter which m sures RF voltages from one millivolt 10 volts at frequencies up to 1,000 mc now available from Hewlett-Packard Cc pany, Palo Alto, Cal. Readings are v tually free from the temperature effe normally associated with sensitive RF r ters.

The new millivoltmeter, model 411 includes two linear voltage scales in a ratio. These linear scales, an outstand feature of the instrument, help elimin scale reading errors and provide maxim voltage resolution. The meter also inclu a db scale for readings from —42 to + db.

Accuracy from one mc to 50 mc ± three per cent of full scale; 50 mc 150 mc, ± six per cent of full scale, a 500 kc to 1,000 mc, ± one db. Becau of the millivoltmeter's high temperatu stability, accuracy changes are negligil from 10° to 40° C.



Voltage range of the Model 411A is millivolts rms full scale to 10 volts r full scale in seven ranges. The unit p vides full scale readings of 0.01, 0. 0.1, 0.3, one, three and 10 volts rms.

Model 411A is equipped with a pen ty probe tip, 500 kc to 50 mc. Extra scre on probe tips include units for high f quency measurement, for measuring on well as at the termination of coax tra mission lines, and a capacity divider creasing the instrument's voltage capabil to 1,000 volts. The Model 411A millivoltmeter is priced at $450. Its c rent availability is nine weeks.

Circle Reader Service Card 75

—*mwj*—

PRECISION WAVEGUIDE BENDING
TO YOUR SPECIFICATIONS
Bends, Twists, Offsets, Coils, Transitions, Fabrications and complete assemblies to your prints.

Specialty
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CORPORATION

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TEL. BRowning 2-0800

Circle Reader Service Card 62

PEREX ANNOUNCES NEW GRID "AMPLIFRAMES"

wo new "PQ" (Premium Quality) 10,000 hour frame grid pliframes," type 7737 and type 7308, designed to with-d high shock and vibration (freedom from microphonics is ntial in critical military and industrial applications) have announced by Amperex Electronic Corp., Long Island,

ype 7737 is a broadened amplifier pentode, similar to type 3, and is designed for critical airborne applications, coaxial e amplifiers, and video and broadband IF amplifiers in munications links and TV equipment.

ype 7308 is a high gain, twin triode, similar to the 6922, is designed for use in radar, oscilloscopes, computers, dband amplifiers and critical airborne applications.

oth "Ampliframe" types incorporate new construction fea- es which result in an absence of microphonics, low noise, ability to withstand shock and vibration.

ype 7308 has a transconductance of 12,500 micromhos, an emely low noise factor of 4.5 db, and very low micro-nics.

Circle Reader Service Card 82

—mwj—

ECTRICALLY CONTROLLED COAX. ATTENUATOR DEVELOPED

miniature coaxial remote controlled attenuator which rates at a speed of .005 sec. has been developed by Don- Electronics Inc., Santa Monica, Cal.

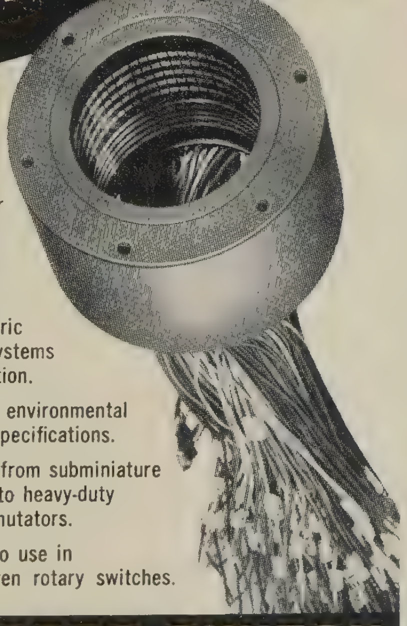
he high speed unit produces a "straight-through" coaxial nection (type "N") when voltage is applied. Upon re-al of operating voltage, the unit becomes a 20 db bi-ctional attenuator, usable from 50 mc to 3500 mc, with haracteristics.

he unit, weighing only 2.85 oz., is available for 28 volts or 115 vac 400 cycle ac operation, and meets MIL-E 5272C ronmental requirements.

Circle Reader Service Card 83

(*Continued on page 106*)

MOTOR-DRIVEN
ROTARY SWITCHES



Special designs
to meet your
performance
specifications for
high-speed
precise
multi-circuit
switching
in complex electric
and electronic systems
and instrumentation.

Built to meet severe environmental conditions and MIL specifications.

Capacities and sizes from subminiature dry-circuit selectors to heavy-duty power-handling commutators.

Write for check-list to use in specifying motor-driven rotary switches.

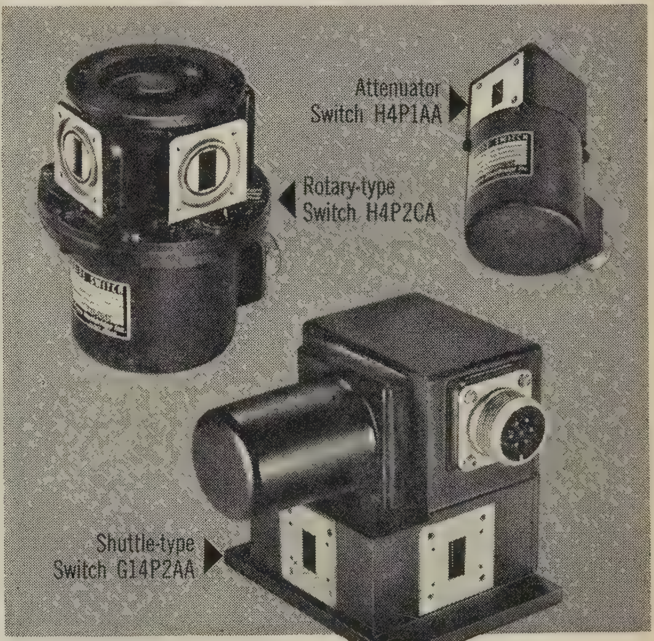
ELECTRO SWITCH CORP.
SLIP-RING DIVISION,
OSTERVILLE, MASSACHUSETTS

Circle Reader Service Card 63

TAPCO
MICROWAVE
COMPONENTS

K$_u$ Band Waveguide Switches

These new TAPCO components fulfill a critical switching function in an advanced missile system and are now available to industry for general K$_u$ Band applications.



SPECIAL FEATURES

The shuttle switch permits switching under full power and when used in conjunction with the auxiliary attenuator switch provides 120 db isolation.

The attenuator switch when used separately provides 80 db isolation, low VSWR, and negligible insertion loss.

The rotary switch is a high-performance, fast-acting, failsafe device with low VSWR and insertion loss.

These features are available from TAPCO in switches covering all frequency ranges. Data sheets available on request.

Advanced engineering projects at TAPCO offer excellent career opportunities for qualified engineers and scientists. Write Employment Director.

TRW
TAPCO GROUP
Thompson Ramo Wooldridge Inc.
Dept. MJ 1160 • Cleveland 17, Ohio

DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE AND SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES

Circle Reader Service Card 64

New Products

(*Continued from page 105*)

HAIR AND FOAM TYPE ABSORBERS AVAILABLE

Designed to simplify installation in shielded anechoic test chambers having ferrous metal walls, B. F. Goodrich Sponge Products, Shelton, Conn., now offers both hair and foam type microwave absorbers backed with flexible magnetic strips.

This permanent plastic magnet, a BFG Koroseal product, eliminates the use of adhesives, brackets, etc., reducing installation time and costs.

A feature of the mounting arrangement permits BFG Microwave Absorbers to be removed from a chamber for temporary use in other experiments. Because this method is non-destructive, the absorbers can be used in other applications when the anechoic chamber is no longer needed.

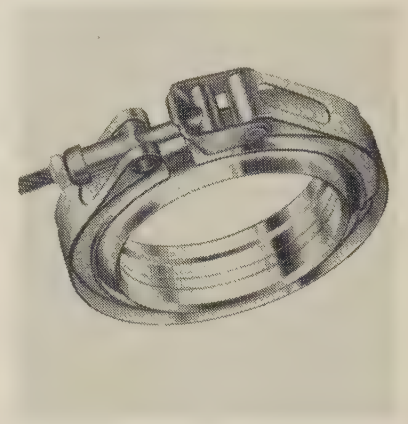
Circle Reader Service Card 76

—*mwj*—

CONOSEAL JOINTS ELIMINATE RADIO FREQUENCY LEAKAGE

Marman Division, Aeroquip Corp., Los Angeles, Cal., has announced all-metal Conoseals which solve joining problems on rigid coaxial lines and other equipment that must conform to requirements of MIL-I-26600 specifications. They can be used on any joint where standard flanges are now located. A 60 per cent weight savings is offered over standard industry flanges and they are useful for applications with space limitation. Uniform flange loading of the Conoseal assures no flange distortion.

Assembly costs can be cut by using the Conoseal with its quick-coupler latch. Installation can be made in seconds, while disassembly is easily made where quick break-away is desired. This all-metal joint assures unlimited shelf life and long operating service. Certain versions will maintain a perfect seal at temperatures from —300°F to +2000°F with pressures up to 20,000 psig.



In addition to standard in-stock Conoseal couplings, Marman also manufactures special couplings for electronic equipment in many materials and configurations.

Circle Reader Service Card 77

—*mwj*—

WAVEGUIDE

SPECIALISTS IN CLOSE TOLERANCE BENDING AND FORMING

INTASPACE CORP.

135 ORANGE ST., BLOOMFIELD, N. J.

PIlgrim 8-4700

Circle Reader Service Card 65

SPERRY DEVELOPS REFLEX OSCILLATOR KLYSTRON

Sperry Electronic Tube Division Sperry Rand Corp., Gainesville, Fla., announced the development of a new flex oscillator klystron.

The new tube operates efficiently over full frequency range *without* a variation reflector voltage. As a result, an expens potentiometer is eliminated from the t installation. Additional cost and wei reductions are realized from the elimi tion of precision gearing previously quired to track reflector voltage as tube is tuned. Simplification of the t installation also results in an increase over all system reliability. Developm has been performed on a tube operating U band frequencies, and work leading an X band tube is well under way.

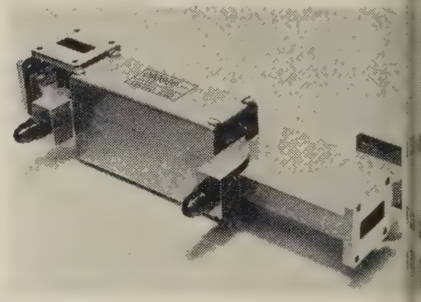
SPE
SRU-
KLYST
MADE IN

Heart of the new tube is a radical r tuner design which places the reflector a fixed position in relation to the cav This permits operation of the tube ab its one-half power points over a wide quency range without varying the flector voltage.

Circle Reader Service Card 78

—*mwj*—

NEW HIGH POWER CIRCULATO AVAILABLE FROM RANTEC



Rantec Corp., Calabasas, Cal. has m available a new line of high power culators in X and C-bands. These u employ lightweight aluminum construct and are made with integral water jack for cooling when used at the higher po applications.

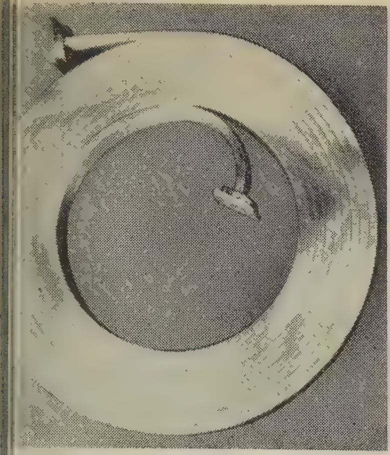
Model CXL-200 pictured herein is ty cal of these advanced ferrite circulators has the following specification: Freque range 8.5 to 9.6 kmc; Isolation 20 minimum; loss 0.6 db maximum; VSV 1.2 to 1 maximum; Power handling megawatt peak, 1000 watts average.

Model CXL-200 is available on 30 delivery.

Circle Reader Service Card 79

—*mwj*—

NIATURE X-BAND DELAY LINE ANNOUNCED



urbo Machine Co., Lansdale, Pa., has ounced a reduction in the physical of conventional X-band delay lines. new technique provides the same delay package whose physical size is re- ed as much as 50 per cent over con- ional X-Band delay lines. The size re- ion has been accomplished while main- ng the same low loss and low re- ion properties of the Turbo standard lines.

urbo is able to supply these delay lines as individual units or as packaged blies in fixed or variable lengths. s, interconnections and adapters are lable as separate items.

Circle Reader Service Card 80

— *mwj* —

APPLIED TECHNOLOGY INTRODUCES RECEIVING MULTICOUPLER

new wideband VHF receiving multi- ler, recently introduced by Applied hnology, Inc., Palo Alto, Cal., permits use of as many as six receivers from a le antenna while affording high system itivity. The unit, which covers the plete 30 to 260 mc frequency range hout tuning, is designed for wideband ctrum monitoring, telemetry, air-to- und communications, and similar ap- ations.

he noise figure of the multicoupler, del VHM-2, is eight db maximum en operated in a 52-ohm system. The t provides a nominal gain of 15 db ween its input and any output, afford- system sensitivity even when employed h receivers having high noise figures.

solation between multicoupler outputs 40 db minimum; between outputs and ut. 70 db minimum. Intermodulation ducts, referred to the input, are at t 40 db down with respect to inter- ence-producing signals having levels of 0 dbm or less.

he VHM-2, complete with integral ulated power supply, requires only /4 inches of vertical panel space. ver requirements are 200 VA at either or 230 volts, 50-60 cycles. Detailed cifications on the VHM-2, which is ced under $3000, are available from manufacturer.

Circle Reader Service Card 81

— *mwj* —

DIRECTIONAL COUPLERS • RF LOAD RESISTORS
COAXIAL TUNERS • RF WATTMETERS • VSWR METERS

MicroMatch® RF Power and VSWR measuring instruments are rugged and accurate in both field and laboratory use. The patented circuit produces an output essentially *independent of frequency*. Over 3800 models of coupler units available. MICRO-MATCH instruments meet highest government and commercial standards, combine highest quality with low cost.

RF POWER and VSWR Instruments

Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
263	0.5 - 225	0 - 10; 100; 1000	Type N* 52 ohms
706N	28 - 2000	0 - 400	Type N* 52 ohms
711N	25 - 1000	0 - 30; 75; 300	N plus 83-1R Adapters
712N	25 - 1000	0 - 2.5; 5; 10	N plus 83-1R Adapters
722N	1000 - 3000	0 - 4	Type N 52 ohms
723N	1000 - 3000	0 - 12	Type N 52 ohms
405B8	28 - 2000	0 - 4000	1⅝" Flange 51.5 ohms
445A10	20 - 2000	0 - 40,000	3⅛" Flange 50.0 ohms

DC OUTPUT DIRECTIONAL COUPLERS

Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
576N1	42 - 2000	1.2	Type N* 52 ohms
576N6	28 - 2000	0 - 400	Type N* 52 ohms
596N2	1000 - 3000	0 - 4	Type N 52 ohms
596N3	1000 - 3000	0 - 12	Type N 52 ohms
402B8	28 - 2000	0 - 4000	1⅝" Flange 51.5 ohms
442A9	28 - 2000	0 - 12,000	3⅛" Flange 50.0 ohms

RF OUTPUT DIRECTIONAL COUPLERS

Model No.	Frequency Range (mcs.)	Coupling Attenuation	RF Connectors and Impedance
313N3	300 - 2000	30 db	Type N* 52 ohms
313N5	60 - 2000	50 db	Type N* 52 ohms
442A40	200 - 1000	40 db	3⅛" Flange 50.0 ohms

ABSORPTION TYPE RF WATTMETERS

Model No.	Frequency Range (mcs.)	Power Range (watts)	RF Connectors and Impedance
621N	1 to over 1000	0 - 120 milliwatts	Type N* 52 ohms
625C5	50 - 1000	0 - 120	Type C 50 ohms
651N	25 - 1000	0 - 25; 100; 500	Type N 52 ohms
611A7	50 - 1000	0 - 1200	3⅛" Flange 50 ohms
612A	44 - 1000	0 - 6000	3⅛" Flange 50 ohms

RF LOAD RESISTORS

Model No.	Frequency Range (mcs.)	RF Power Dissipation (watts)	RF Connectors and Impedance
603N	3000	20 (air cooled)	Type N 52 ohms
633N	3000	50 (air cooled)	Type N* 52 ohms
636N	3000	600 (air cooled)	Type N* 52 ohms
638A	2000	6000 (water cooled)	3⅛" Flange 50.0 ohms

CALORIMETRIC TYPE Primary Standard of RF Power

Model No.	Frequency Range (mcs.)	Power Range	RF Connectors and Impedance
641N	0 - 3000	0 - 3; 10; 30; 100; 300	Type N 52 ohms

COAXIAL LINE TUNERS

Model No.	Frequency Range (mcs.)	Range of Correction	RF Connectors and Impedance
151N	200 - 1000	Tunes a load with a VSWR of 2.00 max. down to a VSWR of 1.00	Type N 50 ohms
152N	500 - 4000		Type N 50 ohms

*Also available with UHF, C and HN Connectors

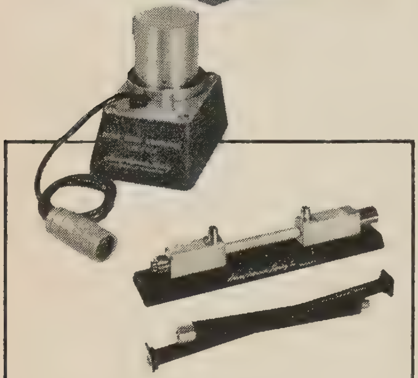
For more information, write:

M.C. Jones

M. C. JONES ELECTRONICS CO., INC.
185 N. MAIN STREET, BRISTOL, CONN.
SUBSIDIARY OF THE Bendix CORPORATION

Circle Reader Service Card 66

Noise Generators for All Frequencies from 10 mc to 40 kmc



The AIL Type 70 series of Noise Generators provide the most complete frequency coverage available. Argon gas discharge tubes are used resulting in stable operation and a secondary standard of relative excess noise temperature. All models may be powered by the Type 74 Automatic Noise Figure Indicator or, the the Type 71 Power Supply.

- 8 Waveguide Units:
  2.6-40 kmc
- 1 Coaxial Unit:
  0.2-2.6 kmc
- 2 Diode Units:
  10-300 mc
- Relative Excess Noise Temperature: *15.28 db*
- Accuracy:
  ±0.25 db: 50 ohm output

Write for complete description.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

FINANCIAL NEWS

CWS WAVEGUIDE TO ACQUIRE MEGADYNE ELECTRONICS

CWS Waveguide Corp., Lindenhurst, Long Island, will acquire all the assets and liabilities of Megadyne Electronics, Inc., Port Chester, N.Y., it has been announced. Terms of the merger have been agreed upon by both managements and will be submitted for the approval of stockholders. The acquisition is being made by an exchange of 569,000 common shares of CWS Waveguide on a share-for-share basis.

CWS Waveguide Corp. is a manufacturer of microwave components for the radar and communications industries. Megadyne Electronics is engaged in the research, design and development of miniaturized magnetic components, electronic filters and other electronic equipment.

Both companies are publicly-owned. Megadyne Electronics also controls a majority interest in Northeast Telecommunications, Inc., Plantsville, Conn., which is engaged in the design and construction of two-way mobile radio communications units and allied electronic products. Megadyne Electronics, Inc., also has a working arrangement with York Research Corp., Stamford, Conn., which does all types of electronic, commercial and military testing, as well as general marketing research.

—*mwj*—

SANDERS 1961 SALES VOLUME ESTIMATED AT $25 MILLION

In a speech recently before the New York Society of Security Analysts, President Royden C. Sanders, Jr. of Sanders Associates, Inc., Nashua, N.H., stated he estimates the company's sales volume for 1961 could reach more than $25 million with a possibility of an operational rate at the $30 million level. He pointed out that heavy deliveries scheduled for the last quarter of fiscal 1961 could modify these figures slightly.

Mr. Sanders also revised his prior expectations for income per share as released some weeks ago. At that time, he stated that earnings for fiscal 1960 would be 90 cents per share. "However," Sanders said, "since that announcement, some sharp improvements have lead us to expect our year end audit to show net earnings of not less than $1 per share.

He continued by saying, "we expect that income per share for the new fiscal year which began August 1st will be not less than $1.50 per share." Currently, Sanders Associates is working on projects in several diversified areas which offer extensive production for the coming year and beyond.

Sanders Associates sales volume for fiscal 1960 is over $17 million. This new high in sales combined with a backlog of $50 million puts Sanders in the ranks of top ten New England direct military pliers.

—*mwj*—

LITTON ANNOUNCES 50% INCREASE IN EARNINGS

After-tax earnings of approxima $7,450,000, or a 50 per cent increase the comparable earnings of $4,954, from operations in the previous year, announced in a preliminary report of ton Industries' 1960 fiscal year by Cha B. Thornton, president and chairman the board. The Beverly Hills, Cal. c pany's 1960 fiscal year ended July 31.

The earnings reported are after provis for approximately $7,750,000 in fed and foreign taxes.

Earnings on a per share basis for 4,158,602 shares of common stock standing amounted to approximately $1 for the year. Per share earnings f operations last fiscal year, adjusted for November 1959 2 for 1 stock split, $1.33.

Thornton earlier had reported sales the 1960 year rose to approxima $185,000,000, a gain of almost 50 cent over the previous year when f figures showed $125,252,561. Thorn said sales are currently running at annual rate of more than $200,000,00

On Aug. 2, Litton voted a 2 1/2 cent stock dividend for stockholders record Oct. 7, 1960. This is the sec stock dividend in the company's hist The first was announced in Novem 1958.

—*mwj*—

AEL REPORTS SALES, BACKLO INCREASE

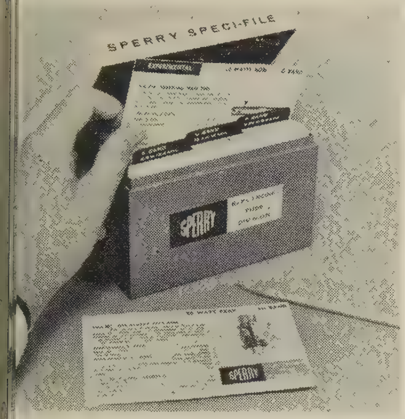
American Electronic Laboratories, I Philadelphia, Pa. reports that sales for present fiscal year (ended August were 23 per cent ahead of those durin similar period last year.

Sales for the first nine months A.E.L.'s fiscal year were $1,784,958, from $1,445,788. This increase occur despite the retarding effect of the gen slowdown in the electronic industry ing the second and third quarters. fact, during the third quarter, the c pany received a substantial amount new orders resulting in a 36 per sales backlog increase over last year.

The company's expansion plans incl a new Semiconductor Division at La dale, Pa. to explore and develop a line microwave and solid-state components devices. This solid-state division is pected to provide a considerable boost sales during fiscal 1962.

—*mwj*—

SPERRY INTRODUCES "SPECI-FILE"



Sperry Electronic Tube Division, inesville, Fla., announces the availa- ity of the "Sperry Speci-File" — a w approach to the presentation of cata- data on klystron and traveling wave crowave tubes.

A handsomely painted 4 x 6 inch tal file box, the "Speci-File" has one d devoted to each tube in the Sperry Information on the card com- ses a complete electronic and physical graphy of the tube. The file is com- hensively indexed to aid in rapid ation of tubes and transfer of data to gineering work sheets. Cards are rted and indexed according to frequen- band, and are color-coded to show e function of each tube.

The Sperry Speci-File is available free engineers and others engaged in the lection and specification of microwave bes.

Circle Reader Service Card 84

—*mwj*—

P APPLICATION NOTE DESCRIBES LATEST FREQUENCY MEASURING TECHNIQUES

Latest techniques and equipment for ac- rately measuring frequency from VHF p to and above 18 kmc are described in new application note available from ewlett-Packard Co., Palo Alto, Cal.

The five-page application note (No. 2) resents detailed methods of frequency easurement by using high speed elec- onic counters and various accessories. rincipal accessories include transfer oscil- ators and harmonic mixers which, when ombined with the counters, extend the easurable frequency range up to 18 kmc nd above.

Useful charts and diagrams summarize quipment applicable to the various fre- uency ranges and show typical instru- ent arrangements in each range. Copies f the application note, "Measuring Frequency from VHF up to and above 18 kmc with Transfer Oscillator/Counter Techniques," may be obtained on request.

Circle Reader Service Card 85

—*mwj*—

NEW BROCHURE LISTS MICROWAVE PRODUCTS BY FREQUENCY BAND

A new brochure listing 250 available microwave products by frequency band has been made available by the Special Tube Operations of Sylvania Electric Products Inc., Mountain View, Cal.

The 16-page illustrated brochure includes information on magnetrons, traveling-wave tubes, ferrite devices, microwave diodes, klystrons, waveguide windows and "Rocket" planar triodes. The units shown range from diodes and planar triodes at UHF to backward-wave oscillators at 75 kmc and microwave diodes at 100 kmc. High power devices, including magnetrons with 200 kw output, and traveling wave tubes operating at 1 kw, are also shown.

Entitled "Sylvania Microwave Products Listed by Frequency Bands," the new brochure contains a technical description of each product plus a two-page index to facilitate locating products when only the type number is known.

Circle Reader Service Card 86

—*mwj*—

WR-51 TEST EQUIPMENT DESCRIBED IN NEW BROCHURE

Waveline, Inc., Caldwell, N. J., has published a new four-page brochure illustrating and describing a complete line of microwave test equipment in the WR-51 waveguide size.

This literature presents over 50 new items of quality precision test equipment that has been designed to operate in the WR-51 waveguide size over a frequency range of 15.0 to 22.0 kmc. Included in the brochure are numerous pictorial illustrations of this equipment as well as a summary listing of each individual model with description and price information.

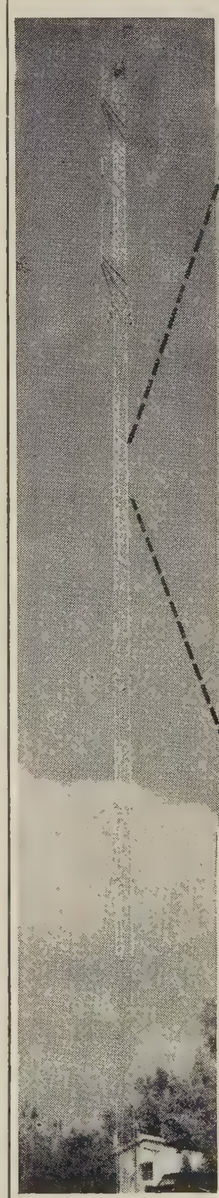
The instruments listed are: various types of attenuators; terminations — fixed and sliding, high and low power; tees — matched and unmatched; frequency meters; crystal mounts; couplers — crossguide, narrow wall, and broad wall; transitions — to RG-91/U and RG-53/U; tuners — slide screw and magic tee adjustable; straight sections, elbows and twists; additional accessories.

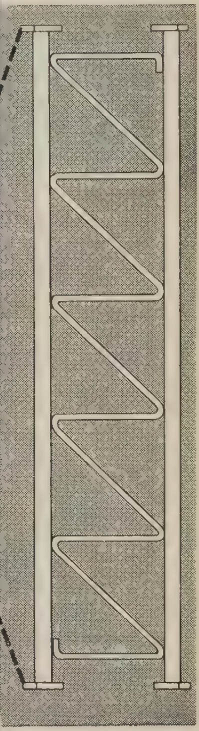
Circle Reader Service Card 87

—*mwj*—

ROHN COMMUNICATION TOWER *No. 60*

for height up to 630 feet!





Shown here is a ROHN No. 60 tower installed to a height of 200 feet with 3 five-foot side arms, mounting antenna for police radio communications.

★ This extremely heavy duty tower is designed for a wide variety of communications of all kinds.

★ This No. 60 ROHN tower is suitable for height up to 630 feet when properly guyed and installed.

★ Completely hot-dipped zinc galvanized after fabrication.

★ Designed for durability, yet economical — easily erected and shipped. ROHN towers have excellent workmanship, construction and design. Each section is 10 feet in length.

FREE

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Phone 7-8416

"Pioneer Manufacturers of Towers of All Kinds"

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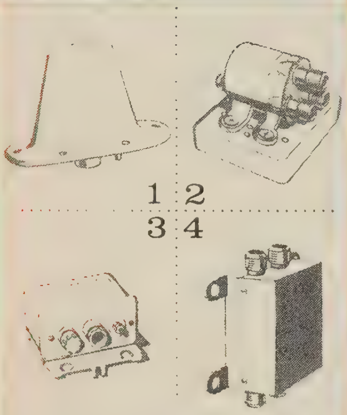
by
ELECTRONIC SPECIALTY CO.



1 **L-BAND ANTENNA LB–247 - Designed for F-104**
Range .... 960 to 1220 mc
VSWR .... <1.7:1
Power .... 2 kw (peak)
Polarization .... vertical
Qualification MIL-A-25708
Weight .... < 8 Oz.

2 **MINIATURE CO-AXIAL SWITCH CS–319**
Power Handling ...... 200 W cw - 3 kw peak @ 0.1% duty cycle
RF Voltage .... 1000 min.
Operating Voltage .... 18 - 30 vdc
VSWR .... 1.2:1 max. to 1250 mc
Insertion Loss .... 0.2 db max.
Isolation ..... 40 db down to 1250 mc
Qualification MIL-S-25878

3 **ANTENNA SELECTOR RY–472G**
Switching Rate .... 70 ± 15 cpm
Life .... >500 Hours
Input Power .... 24-29 vdc
Output Power 2 amp. ind. @ 28 vdc
Power Consumption . . 7 watts max.
Qualified MIL-E-5272
Weight .... 3 lbs. max.

4 **DIPLEX FILTER DP–318**
Frequency .... 950 to 1215 mc
Filter Characteristics per Air Force Requirement - F-339/A MIL-F-25880
VSWR .... <1.4:1
R F Power .... 2 kw peak; 2 watts average
Weight .... 3.0 lbs.

ES development engineers welcome the opportunity to furnish an engineering estimate on your specific requirement. Emergency circumstances given special consideration. Ask for the RADIATING SYSTEMS design folder.

RADIATING SYSTEMS
DIVISION
ELECTRONIC SPECIALTY CO.
CORPORATE OFFICES:
5121 San Fernando Road
Los Angeles 39, California
CHapman 5-3771

New Literature

(*Continued from page 109*)

OSCILLATOR DATA SHEETS AVAILABLE TO INDUSTRY

Technical data sheets from John Gombos Co., Inc., Clifton, N.J., on their new Miniature "C" Band Triode Oscillator Model 151C are now available to industry.

Model 151C Miniature Triode Oscillator, with a power output of 65 milliwatts minimum at 4200 Mc and 20 milliwatts minimum at 6000 Mc, is only 4 1/2 ounces in weight. This Miniature "C" Band Triode Oscillator covers the range of frequencies from 4200 Mc to 6000 Mc in 50 Mc steps. Each oscillator is designed for maximum stability having temperature stability of ±10 kc per degree C, minimum size, maximum output and has a vernier (50 Mc) control of frequency. Only plate voltage 200V nominal and 6.3V for filaments are required, thus simplifying power problems.

The 151C also features pre-set tuning. This tiny unit may be applied as a local oscillator, CW signal source and driver for crystal harmonic generators.

Circle Reader Service Card 88

—*mwj*—

SHORT-FORM CATALOG DESCRIBES RESDEL ENGINEERING CORPORATION PRODUCTS

A new short-form catalog describing the products of Resdel Engineering Corp., Pasadena, Cal., is now available.

This short-form catalog contains photographs and specifications for the Resdel high-reliability line of miniature VHF — UHF amplifier cavities, phaselock receiver, subminiature RF—IF crystal-controlled oscillator multiplier modules, Doppler radar velocimeter, 960/108-mc converter, VHF—UHF wideband antenna amplifiers and receiver multicouplers, X-band signal generator, radar transmitters, and UDOP tracking system components.

Circle Reader Service Card 89

—*mwj*—

FERRITE MATERIALS SURVEY FEATURED IN PUBLICATION

A survey of ferrite materials is the feature article of the latest issue of *Applied Magnetics*, the quarterly technical publication of Indiana General Corp., Valparaiso, Ind. In the article, four main groups of ferrite materials are discussed and illustrated, including "soft" ferrites, "hard" ferrites (permanent magnets) and ferrites used in memory products. A handy ferrite application chart summarizes the information both by usage and magnetic characteristics.

Another timely article is titled "Methods of Plating Alnico Magnet Problems involving cast and sinter Alnico are discussed, and a step-by-st guide for plating cast Alnico with ca mium is provided.

Copies of the magazine are availat on request.

Circle Reader Service Card 90

—*mwj*—

ORION PUBLISHES EIGHT-PAGE BULLETIN

A new catalog describing the company line of modular IF amplifiers, automat frequency controls for klystrons, micr wave/IF converters and high temperatu transistorized power supplies, is a nounced by the Orion Electronic Cor of Tuckahoe, N.Y.

The eight-page, two color bulletin giv engineering information on all of t various models. Copies are availabl without charge.

Circle Reader Service Card 91

—*mwj*—

"C" BAND TRIODE OSCILLATOR DATA SHEET NOW AVAILABLE

Technical data sheets on the new Joh Gombos Co., Inc., Clifton, N.J., "C Band Triode Oscillator Model 101C a now available to industry.

The Model 101C is continuously tu able in 500 mc minimum steps fro 4200 mc to 6000 mc, is only nine oz. i weight, offers stability at 20 G's, an simplifies power problems since only plate voltage of 175 volts and 6.3 vol for filaments are required. This uniqu oscillator serves as a general purpos member of a family of oscillators desig ed around the General Electric GL-513 ceramic triode. Model 101C has appl cations as local oscillators, CW sign sources and drivers for crystal harmoni generators.

The technical data sheets can be obtained on request.

Circle Reader Service Card 92

—*mwj*—

SUPERPOWER HIGH VOLTAGE RECTIFIER MANUAL PUBLISHED

A 16-page manual published by International Rectifier Corporation, El Segund Cal., provides complete specifications, elec trical principle and operating data on new series of Superpower High Voltag Rectifier Columns. Capable of new high in power handling capacity, Superpowe Rectifiers may be built for voltages ranging from 10,000 to 120,000 volts, wit

(*Continued on page 112*)

втоматический перевод,
вычислительные машины
способствуют исследова-
нию языков

AUTOMATIC TRANSLATION
INDEXING
ABSTRACTING

To formulate rules for automatic language translation is a subtle and complex task. Yet, significant progress is being made. During the past several years large amounts of Russian text have been translated and analyzed at Ramo-Wooldridge's Intellectronics Laboratories using several types of existing general purpose electronic computers.

Many hundreds of syntactic and semantic rules are used to remove ambiguities otherwise present in word-for-word translation. The considerable improvements that have been effected during the progress of this work indicate that it may be possible within the next year or so to produce, for the first time, machine translation of sufficient accuracy and at sufficiently low cost to justify practical application. Electronic computers are also invaluable for other language research activities at Ramo-Wooldridge.

Techniques for automatic indexing, automatic abstracting, and other aspects of communicating scientific information are also being investigated. Research and development at the Intellectronics Laboratories will eventually lead to electronic machines capable of carrying on self-directed programs of research and analysis and "learning" by their own experiences.

The accelerating pace at which these "communication of knowledge" problems are growing in importance has created challenging career opportunities in new fields of scientific endeavor.

For a copy of our career brochure, "An Introduction to Ramo-Wooldridge," write to Technical Staff Development.

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Brookline 46, Mass.

(*Continued from page 110*)

current output ranging from 1 to 50 amperes.

The new field of superpower rectification is expected to bring significant advances in long-range radar, long range television and communication transmitters, as well as in particle accelerators, induction heating and pulse modulators. For a free copy, write on your letterhead for SR-370, to International Rectifier Corporation, El Segundo, Cal.

—*mwj*—

TRANSISTORIZED DC POWER SUPPLIES DISCUSSED IN GE BULLETIN

Bulletin GED-4184, discusses General Electric's new standard line of precision-regulated, transistorized d-c power supplies for a wide variety of applications in the utility, industrial, military and electronics area.

The 8-page bulletin explains features of the new line of 30 standard units which contain 25 per cent less components and a new "constant watts" protective circuit. Publication contains photographs and charts showing guaranteed specifications of each of the 30 models.

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—*mwj*—

FREE SPACE ROOM DESIGN DISCUSSED IN 12-PAGE HANDBOO

McMillan Industrial Corp., Ipswi Mass., offers a new 12-page bulletin wh provides design engineers for the first ti with a discussion of the many elements free space room design.

Included are charts for estimating ro dimensions according to frequency and tenna size, a table of absorber performan three typical design problems and th solutions, a discussion of specification p falls, and a tear-out free space room des questionnaire.

Circle Reader Service Card 94

—*mwj*—

NEW DATA DIGEST AVAILABI FROM LFE

Laboratory For Electronics, Inc., Bost Mass., has published a new Technical D Digest describing the company's capab ties in Airborne Doppler Navigation s tems.

The eight-page, illustrated brochure tails specifications of these equipments, cluding system philosophy, operatio capabilities and performance, and vari models of the Doppler Navigators p duced.

The Digests are available on request.

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—*mwj*—

IMMEDIATE OPENINGS FOR:

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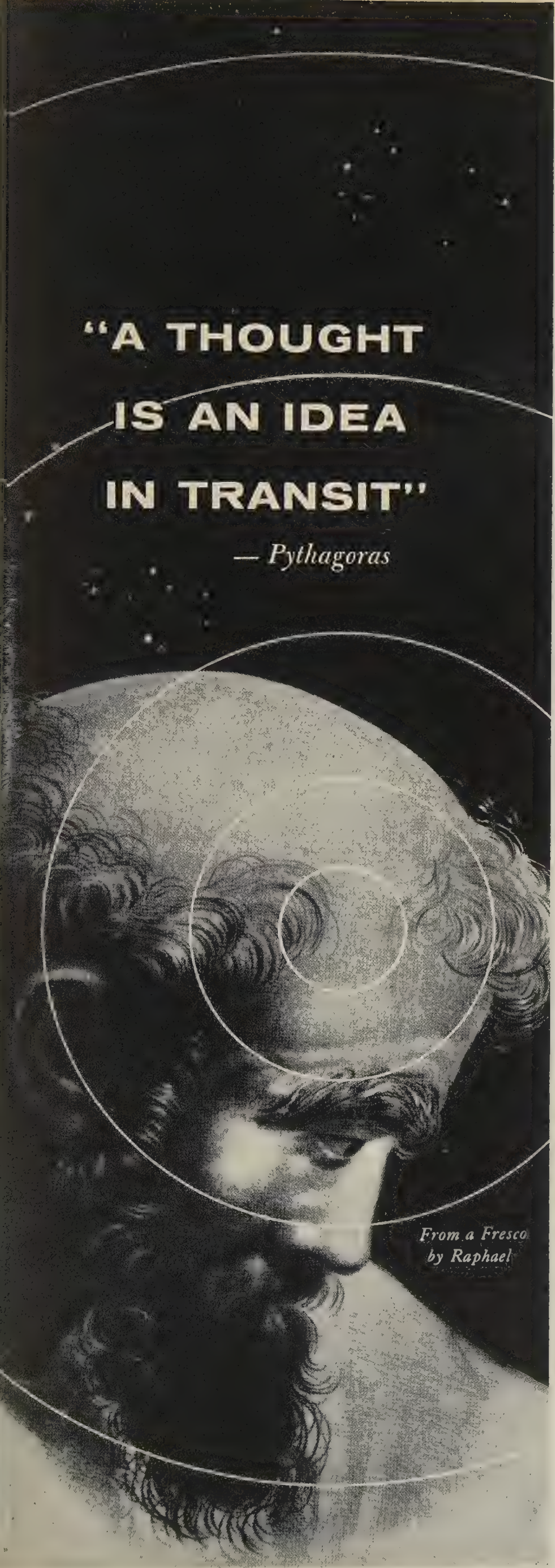
"A THOUGHT IS AN IDEA IN TRANSIT"
— Pythagoras
From a Fresco by Raphael

Ideas in transit . . . once tested, are the essence of research and resultant progress. Progress built upon research has steadily contributed to advancement of microwave theory, technology, and products, by Microwave Associates giving it an excellent position of leadership.

To maintain this leadership, Microwave Associates provides the most capable microwave engineers with the atmosphere and rewards which contribute to continued progress for them and for the company.

Now, Microwave Associates is expanding its research activities with the formation of three new Research and Development Groups. This provides exceptional opportunities for top qualified design engineers (EE & ME) and physicists to join our dynamic organization and to achieve rapid professional advancement by developing their ideas and by working directly with a respected authority in his field.

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an opportunity to work with DR. GRANT ST. JOHN on:

- Long life, low-noise and communication type TWT's
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- Advanced state-of-the-art magnetron devices

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- High power broad-band circulators and isolators
- Novel designs of ferrite limiters and phase shifters
- New semiconductor switches, limiters, and duplexers
- Advanced research on other passive microwave solid state devices

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an opportunity to work with MR. MARION HINES on:

- New tunnel diode solid state oscillators for microwave operation
- Advanced research on solid state amplifiers and down-converters

Backing up these top-notch experts are other equally talented scientists available for consultation in related fields. These include such well-known scientists as Dr. Arthur Uhlir and Dr. Lawrence Gould.

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For further information on these growth opportunities contact Dr. Jerome S. Kornreich.

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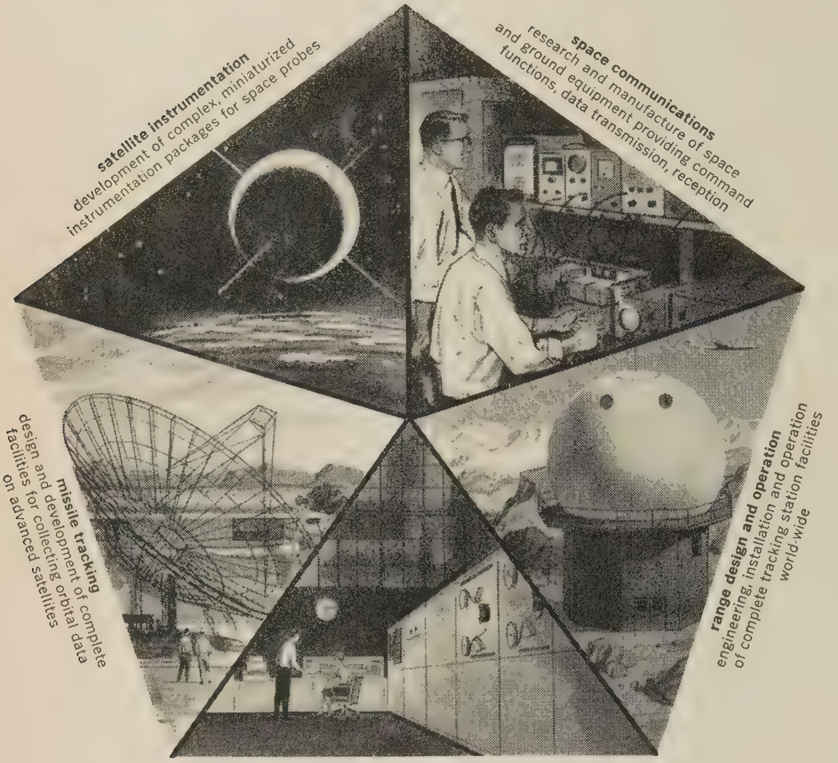
satellite instrumentation
development of complex, miniaturized instrumentation packages for space probes
space communications
research and manufacture of space and ground equipment providing command functions, data transmission, reception
missile tracking
design and development of complete facilities for collecting orbital data on advanced satellites
range design and operation
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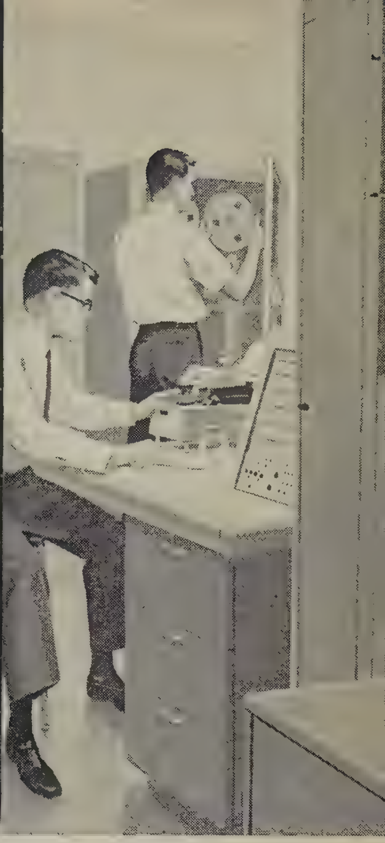

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY IN

ELECTRONICS

Lockheed Missiles and Space Division has made significant contributions in electronics in such areas as: computer development; telemetry; radar and data link transducers and instrumentation; antennas and electromagnetic propagation and radiation; ferrite and MASER research; data reduction and analysis; solid state electronics, including photovoltaic devices, electrochemistry, infrared optics; FM-FM data systems; PAM-PCM data links; and logical design.

Special emphasis is being attached to the research, design and development of improved military electronics systems for communications, including new methods of data transmission, reception and storage. Pioneering work is also being conducted in space vehicle borne computers, DC-AC inverters, non-gyro guidance systems. Studies in oceanography include underwater communication and navigation, and natural phenomena and military aspects of the deep sea.

Lockheed's programs reach far into the future and deal with unknown environmen It is a rewarding future and one that outstanding scientists and engineers are invited to share. If you are experienced in any of the above areas, or in related wor we invite your inquiry. Please write: Research and Development Staff, Dept. F-44, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

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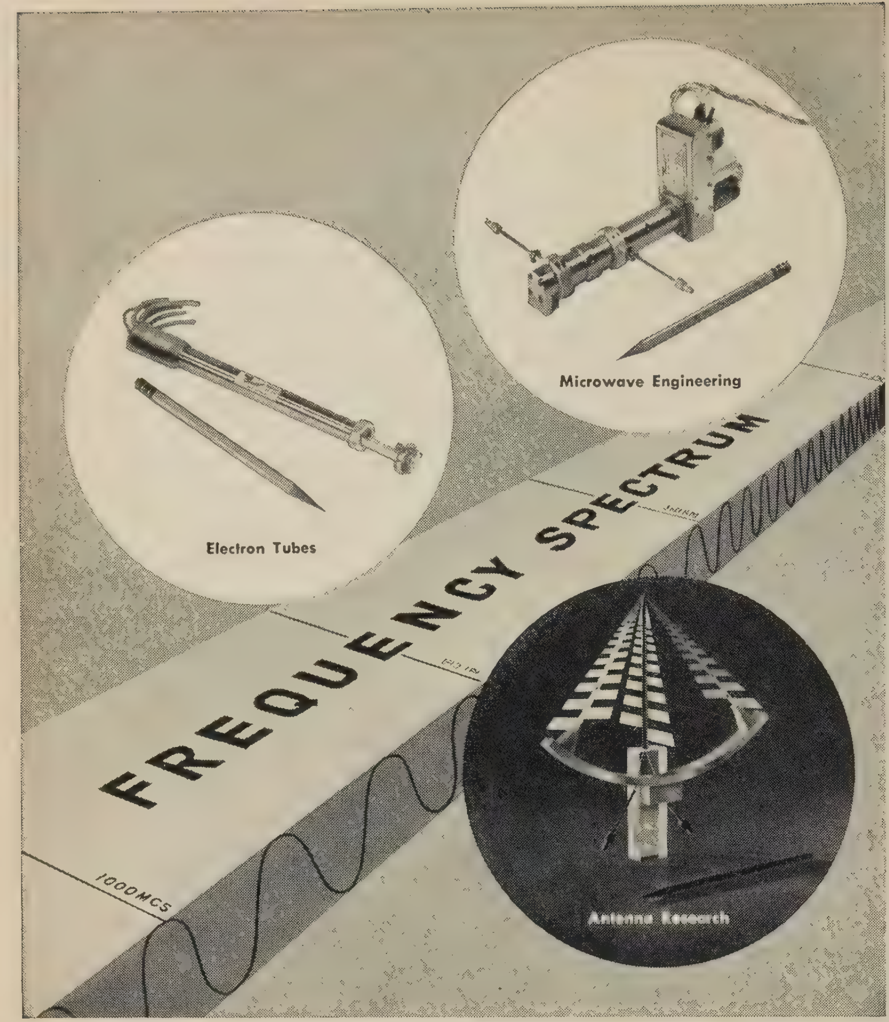

OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of The Bendix Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

ANTENNA RESEARCH in electronic scanning, log periodic antennas, microwave optics.

MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

Investigate these opportunities *now*, where your technical competence and potentialities will receive full recognition in "Building Your Future with Bendix".

If interested, please write or wire A. Capsalis, Research Laboratories Division, The Bendix Corporation, Southfield, Michigan.

Research Laboratories Division
SOUTHFIELD, MICHIGAN

THE Bendix CORPORATION

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PAPERS

We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

Papers can be addressed to:
"the microwave journal," 1330 Beacon St., Brookline, Mass.

— m w j —

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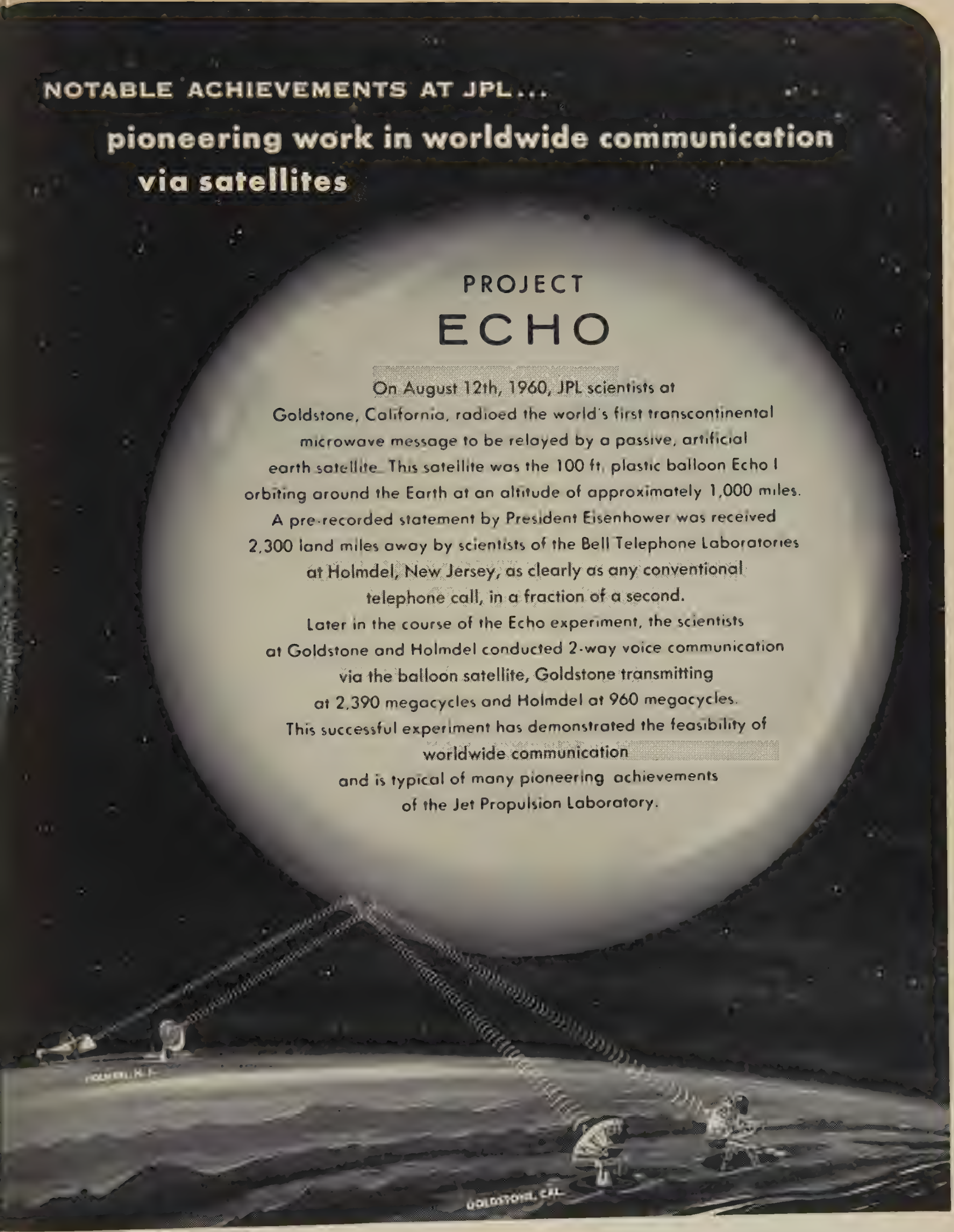
When submitting a change of address, please complete the subscription card inside the back cover of the magazine. Include the address at which you have been receiving *the microwave journal*, and allow one month for the change to become effective.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GOLDSTONE, CAL.

NOTABLE ACHIEVEMENTS AT JPL . . .

pioneering work in worldwide communication via satellites

PROJECT

ECHO

On August 12th, 1960, JPL scientists at Goldstone, California, radioed the world's first transcontinental microwave message to be relayed by a passive, artificial earth satellite. This satellite was the 100 ft. plastic balloon Echo I orbiting around the Earth at an altitude of approximately 1,000 miles. A pre-recorded statement by President Eisenhower was received 2,300 land miles away by scientists of the Bell Telephone Laboratories at Holmdel, New Jersey, as clearly as any conventional telephone call, in a fraction of a second. Later in the course of the Echo experiment, the scientists at Goldstone and Holmdel conducted 2-way voice communication via the balloon satellite, Goldstone transmitting at 2,390 megacycles and Holmdel at 960 megacycles. This successful experiment has demonstrated the feasibility of worldwide communication and is typical of many pioneering achievements of the Jet Propulsion Laboratory.

jpl
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ENGINEERS · SCIENTISTS

Dr. William C. King (Ph.D. Duke University) joined General Electric's Space Sciences Laboratory in 1956, after holding Research Associate appointments at Johns Hopkins and Duke. While with the Laboratory, Dr. King has published a number of papers, the most recent being in the area where he is now concentrating his interests: "Correlation of Telemetry Signal Attenuation Data with Transition from Free Molecular to Continuum Flow."

Communicare In Spatium
NO 3 IN A SERIES

"THEORETICAL AND EXPERIMENTAL STUDIES OF COMMUNICATIONS IN THE PRESENCE OF HIGHLY IONIZED GASES ...a challenging interdisciplinary endeavor at the Missile & Space Vehicle Department"

SAYS Dr. William C. King, COMMUNICATIONS PHYSICIST
AT GENERAL ELECTRIC'S SPACE SCIENCES LABORATORY

"Behind new emphasis at the MSVD Laboratory on the extension of knowledge in this little explored area of communications is the compelling need of space scientists to learn a great deal more about the physical phenomena encountered by a satellite or missile nose cone during re-entry.

"Every flight of a space vehicle should increase our store of information. This objective, however, can be met only if the results of measurements made in or near the vehicle can be delivered to the ground.

"Radio telemetry seeks to provide this link but during the crucial re-entry period the presence of highly ionized gases can make such communications difficult or impossible.

"The study—both theoretical and experimental—of this problem falls into not one but three scientific areas: electromagnetic theory, aerodynamics and physical chemistry. While the group I am leading is concerned principally with the first of these, it is necessary for us to work closely with those in allied areas.

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. . IT IS HARD FOR PEOPLE . . . TO
E HOW . . . ELECTRONICS . . . COULD
SSIBLY GO WRONG"

MARKETING MyOpiA

BY

THEODORE LEVITT

though this article does not deal directly with the
wave industry, it analyzes in some detail the charac-
tics of a "growth industry" and the dangers of pro-
orientation rather than customer orientation. Ap-
ing in two installments, the first deals with product
lescence. The article is reprinted from the July-
ust 1960 issue of the "Harvard Business Review."

RT I

very major industry was once a growth industry. But
e that are now riding a wave of growth enthusiasm
very much in the shadow of decline. Others which are
ight of as seasoned growth industries have actually
ped growing. In every case the reason growth is
atened, slowed, or stopped is *not* because the market
turated. It is because there has been a failure of man-
ment.

eful Purposes

he failure is at the top. The executives responsible for
n the last analysis, are those who deal with broad aims
policies. Thus:

he railroads did not stop growing because the need for
enger and freight transportation declined. That grew.
railroads are in trouble today not because the need
filled by others (cars, trucks, airplanes, even tele-
nes), but because it was *not* filled by the railroads
nselves. They let others take customers away from
n because they assumed themselves to be in the rail-
l business rather than in the transportation business.
reason they defined their industry wrong was because
were railroad-oriented instead of transportation-
nted; they were product-oriented instead of customer-
nted.

ollywood barely escaped being totally ravished by television. Actually, all the established film companies went through drastic reorganizations. Some simply disappeared. All of them got into trouble not because of TV's inroads but because of their own myopia. As with the railroads, Hollywood defined its business incorrectly. It thought it was in the movie business when it was actually in the entertainment business. "Movies" implied a specific, limited product. This produced a fatuous contentment which from the beginning led producers to view TV as a threat. Hollywood scorned and rejected TV when it should have welcomed it as an opportunity — an opportunity to expand the entertainment business.

Today TV is a bigger business than the old narrowly defined movie business ever was. Had Hollywood been customer-oriented (providing entertainment), rather than product-oriented (making movies), would it have gone through the fiscal purgatory that it did? I doubt it. What ultimately saved Hollywood and accounted for its recent resurgence was the wave of new young writers, producers, and directors whose previous successes in television had decimated the old movie companies and toppled the big movie moguls.

There are other less obvious examples of industries that have been and are now endangering their futures by improperly defining their purposes. I shall discuss some later and analyze the kind of policies that lead to trouble. Right now it may help to show what a thoroughly customer-oriented management *can* do to keep a growth industry growing, even after the obvious opportunities have been exhausted; and here there are two examples that have been around for a long time. They are nylon and glass — specifically, E. I. duPont de Nemours & Company and Corning Glass Works:

Both companies have great technical competence. Their product orientation is unquestioned. But this alone does not explain their success. After all, who was more pride-

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fully product-oriented and product-conscious than the e while New England textile companies that have beer thoroughly massacred? The DuPonts and the Corni have succeeded not primarily because of their produc research orientation but because they have been thorou ly customer-oriented also. It is constant watchfulness opportunities to apply their technical know-how to creation of customer-satisfying uses which accounts their prodigious output of successful new products. Wi out a very sophisticated eye on the customer, most of t new products might have been wrong, their sales meth useless.

Aluminum has also continued to be a growth indu thanks to the efforts of two wartime-created compa which deliberately set about creating new customer-sa fying uses. Without Kaiser Aluminum & Chemical poration and Reynolds Metals Company, the total mand for aluminum today would be vastly less than i

Error of Analysis

Some may argue that is is foolish to set the railroads against aluminum or the movies off against glass. not aluminum and glass naturally so versatile that industries are bound to have more growth opportun than the railroads and movies? This view commits cisely the error I have been talking about. It define industry, or a product, or a cluster of know-how so rowly as to guarantee its premature senescence. When mention "railroads," we should make sure we n "transportation." As transporters, the railroads still a good chance for very considerable growth. They not limited to the railroad business as such (though in opinion rail transportation is potentially a much stro transportation medium than is generally believed).

What the railroads lack is not opportunity, but som the same managerial imaginativeness and audacity made them great. Even an amateur like Jacques Ba can see what is lacking when he says:

"I grieve to see the most advanced physical and so organization of the last century go down in shabby grace for lack of the same comprehensive imagina that built it up. [What is lacking is] the will of companies to survive and to satisfy the public by in tiveness and skill."[1]

Shadow of Obsolescence

It is impossible to mention a single major industry did not at one time qualify for the magic appellatio "growth industry." In each case its assumed strength in the apparently unchallenged superiority of its proc There appeared to be no effective substitute for it. It itself a runaway substitute for the product it so tri phantly replaced. Yet one after another of these brated industries has come under a shadow. Let us briefly at a few more of them, this time taking exam that have so far received a little less atention:

Dry cleaning—This was once a growth industry lavish prospects. In an age of wool garments, ima being finally able to get them safely and easily clean. boom was on.

Yet here we are 30 years after the boom started and industry is in trouble. Where has the competition c from? From a better way of cleaning? No. It has c n synthetic fibers and chemical additives that have cut need for dry cleaning. But this is only the beginning. king in the wings and ready to make chemical dry ning totally obsolescent is that powerful magician, ul- onics.

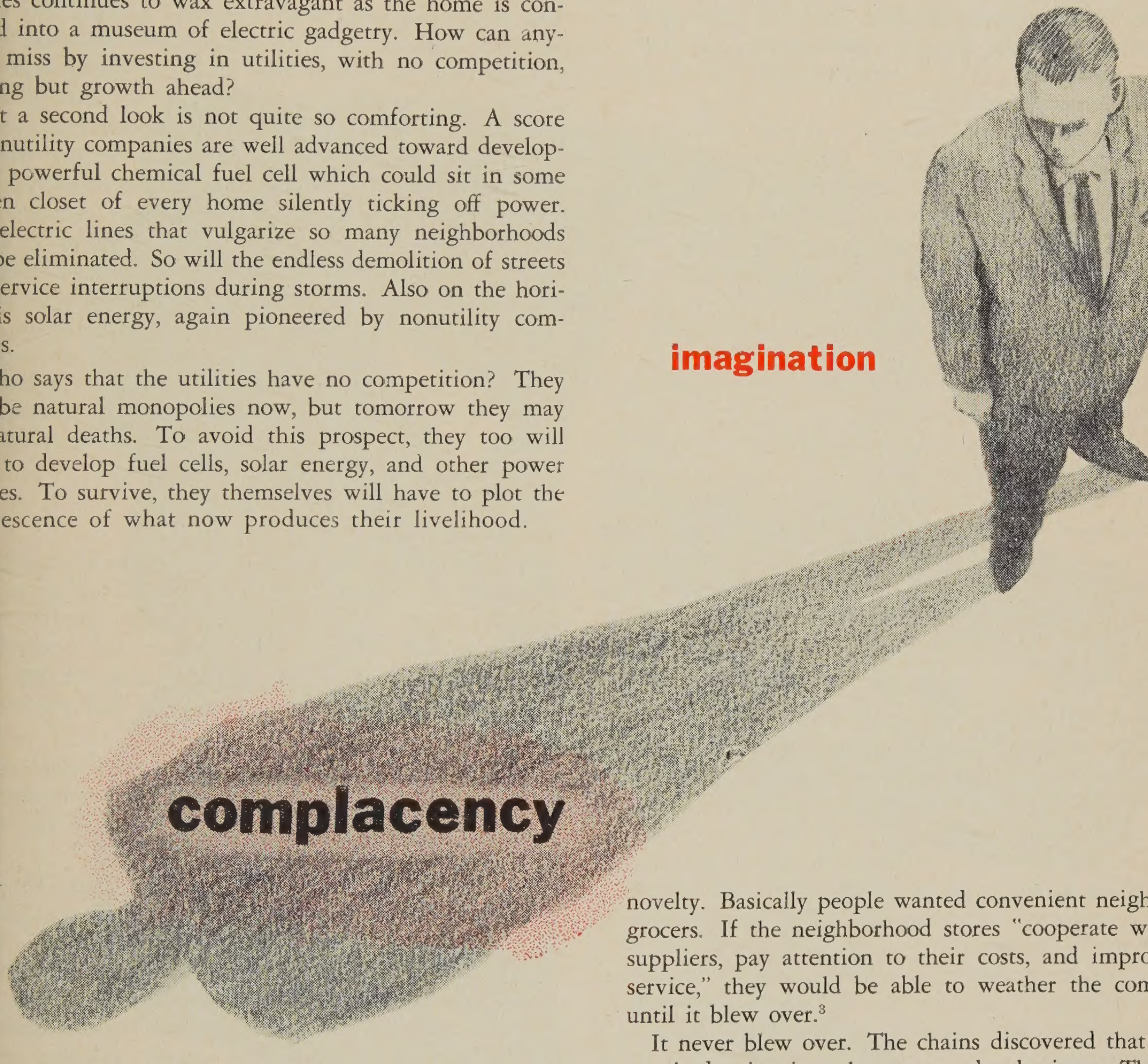
---

[1] Jacques Barzun, "Trains and the Mind of Man," *Hol* February 1960, p. 21.

lectric utilities — This is another one of those sup- edly "no-substitute" products that has been enthroned a pedestal of invincible growth. When the incandes- lamp came along, kerosene lights were finished. Later water wheel and the steam engine were cut to ribbons he flexibility, reliability, simplicity, and just plain easy ilability of electric motors. The prosperity of electric ities continues to wax extravagant as the home is con- ed into a museum of electric gadgetry. How can any- y miss by investing in utilities, with no competition, hing but growth ahead?

ut a second look is not quite so comforting. A score nonutility companies are well advanced toward develop- a powerful chemical fuel cell which could sit in some den closet of every home silently ticking off power. electric lines that vulgarize so many neighborhoods be eliminated. So will the endless demolition of streets service interruptions during storms. Also on the hori- is solar energy, again pioneered by nonutility com- ies.

Who says that the utilities have no competition? They be natural monopolies now, but tomorrow they may natural deaths. To avoid this prospect, they too will e to develop fuel cells, solar energy, and other power ces. To survive, they themselves will have to plot the olescence of what now produces their livelihood.



Grocery stores — Many people find it hard to realize t there ever was a thriving establishment known as the rner grocery store." The supermarket has taken over h a powerful effectiveness. Yet the big food chains of 1930's narrowly escaped being completely wiped out the aggressive expansion of independent supermarkets. e first genuine supermarket was opened in 1930, in naica, Long Island. By 1933 supermarkets were thriving California, Ohio, Pennsylvania, and elsewhere. Yet the ablished chains pompously ignored them. When they ose to notice them, it was with such derisive descrip- ns as "cheapy," horse-and-buggy," "cracker-barrel store- ping," and "unethical opportunists."

The executive of one big chain announced at the time t he found it "hard to believe that people will drive for miles to shop for foods and sacrifice the personal service chains have perfected and to which Mrs. Consumer is accustomed."[2] As late as 1936, the National Wholesale Grocers convention and the New Jersey Retail Grocers Association said there was nothing to fear. They said that the supers' narrow appeal to the price buyer limited the size of their market. They had to draw from miles around. When imitators came, there would be wholesale liquidations as volume fell. The current high sales of the supers was said to be partly due to their novelty. Basically people wanted convenient neighborhood grocers. If the neighborhood stores "cooperate with their suppliers, pay attention to their costs, and improve their service," they would be able to weather the competition until it blew over.[3]

It never blew over. The chains discovered that survival required going into the supermarket business. This meant the wholesale destruction of their huge investments in corner store sites and in established distribution and merchandising methods. The companies with "the courage of their convictions" resolutely stuck to the corner store philosophy. They kept their pride but lost their shirts.

Self-Deceiving Cycle

But memories are short. For example, it is hard for people who today confidently hail the twin messiahs of electronics and chemicals to see how things could possibly go wrong with these galloping industries. They probably also cannot see how a reasonably sensible businessman could have been as myopic as the famous Boston millionaire who 50 years ago unintentionally sentenced his heirs to poverty by stipulating that his entire estate be forever invested exclusively in electric streetcar securities. His posthumous declaration, "There will always be a big demand for efficient urban transportation," is no consolation to his heirs who sustain life by pumping gasoline at automobile filling stations.

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[2] For more details see M. M. Zimmerman. *The Super Market: A Revolution in Distribution* (New York, McGraw Hill Book Company, Inc., 1955), p. 48.

[3] Ibid., pp. 45-47.

Yet, in a casual survey I recently took among a group of intelligent business executives, nearly half agreed that it would be hard to hurt their heirs by tying their estates forever to the electronics industry. When I then confronted them with the Boston streetcar example, they chorused unanimously, "That's different!" But is it? Is not the basic situation identical?

In truth, *there is no such thing* as a growth industry, I believe. There are only companies organized and operated to create and capitalize on growth opportunities. Industries that assume themselves to be riding some automatic growth escalator invariably descend into stagnation. The history of every dead and dying "growth" industry shows a self-deceiving cycle of bountiful expansion and undetected decay. There are four conditions which usually guarantee this cycle:

1. The belief that growth is assumed by an expanding and more affluent population.
2. The belief that there is no competitive substitute for the industry's major product.
3. Too much faith in mass production and in the advantages of rapidly declining unit costs as output rises.
4. Preoccupation with a product that lends itself to carefully controlled scientific experimentation, improvement, and manufacturing cost reduction.

Population Myth

The belief that profits are assured by an expanding and more affluent population is dear to the heart of every industry. It takes the edge off the apprehensions everybody understandably feels about the future. If consumers are multiplying and also buying more of your product or service, you can face the future with considerably more comfort than if the market is shrinking. An expanding market keeps the manufacturer from having to think very hard or imaginatively. If thinking is an intellectual response to a problem, then the absence of a problem leads to the absence of thinking. If your product has an automatically expanding market, then you will not give much thought to how to expand it.

One of the most interesting examples of this is provided by the petroleum industry. Probably our oldest growth industry, it has an enviable record. While there are some current apprehensions about its growth rate, the industry itself tends to be optimistic. But I believe it can be demonstrated that it is undergoing a fundamental yet typical change. It is not only ceasing to be a growth industry, but may actually be a declining one, relative to other business. Although there is widespread unawareness of it, I believe that within 25 years the oil industry m find itself in much the same position of retrospective gl that the railroads are now in. Despite its pioneering w in developing and applying the present-value method investment evaluation, in employee relations, and in wo ing with backward countries, the petroleum business is distressing example of how complacency and wronghe edness can stubbornly convert opportunity into near d aster.

One of the characteristics of this and other industr that have believed very strongly in the beneficial con quences of an expanding population, while at the sa time being industries with a generic product for wh there has appeared to be no competitive substitute, is t the individual companies have sought to outdo their co petitors by improving on what they are already doi This makes sense, of course, if one assumes that sales tied to the country's population strings, because the c tomer can compare products only on a feature-by-feat basis. I believe it is significant, for example, that not si John D. Rockefeller sent free kerosene lamps to Ch has the oil industry done anything really outstanding create a demand for its product. Not even in product i provement has it showered itself with eminence. T greatest single improvement, namely, the development tetraethyl lead, came from outside the industry, specifica from General Motors and DuPont. The big contributi made by the industry itself are confined to the technol of oil exploration, production, and refining.

Asking for Trouble

In other words, the industry's efforts have focused improving the *efficiency* of getting and making its p duct, not really on improving the generic product or marketing. Moreover, its chief product has continuou been defined in the narrowest possible terms, namely, ga line, not energy, fuel, or transportation. This attitude l helped assure that:

—Major improvements in gasoline quality tend not originate in the oil industry. Also, the development superior alternative fuels comes from outside the oil dustry, as will be shown later.

—Major innovations in automobile fuel marketing originated by small new oil companies that are not p marily preoccupied with production or refining. Th are the companies that have been responsible for rapidly expanding multipump gasoline stations, with th successful emphasis on large and clean layouts, rapid a efficient driveway service, and quality gasoline at l prices.

The point of all this is that there is no guaran against product obsolescence. If a company's own search does not make it obsolete, another's will. Unless industry is especially lucky, as oil has been until now, can easily go down in a sea of red figures—just as railroads have, as the buggy whip manufacturers have, the corner grocery chains have, as most of the big mo companies have, and indeed as many other industries ha

NEXT MONTH—A look at the electronics industry.

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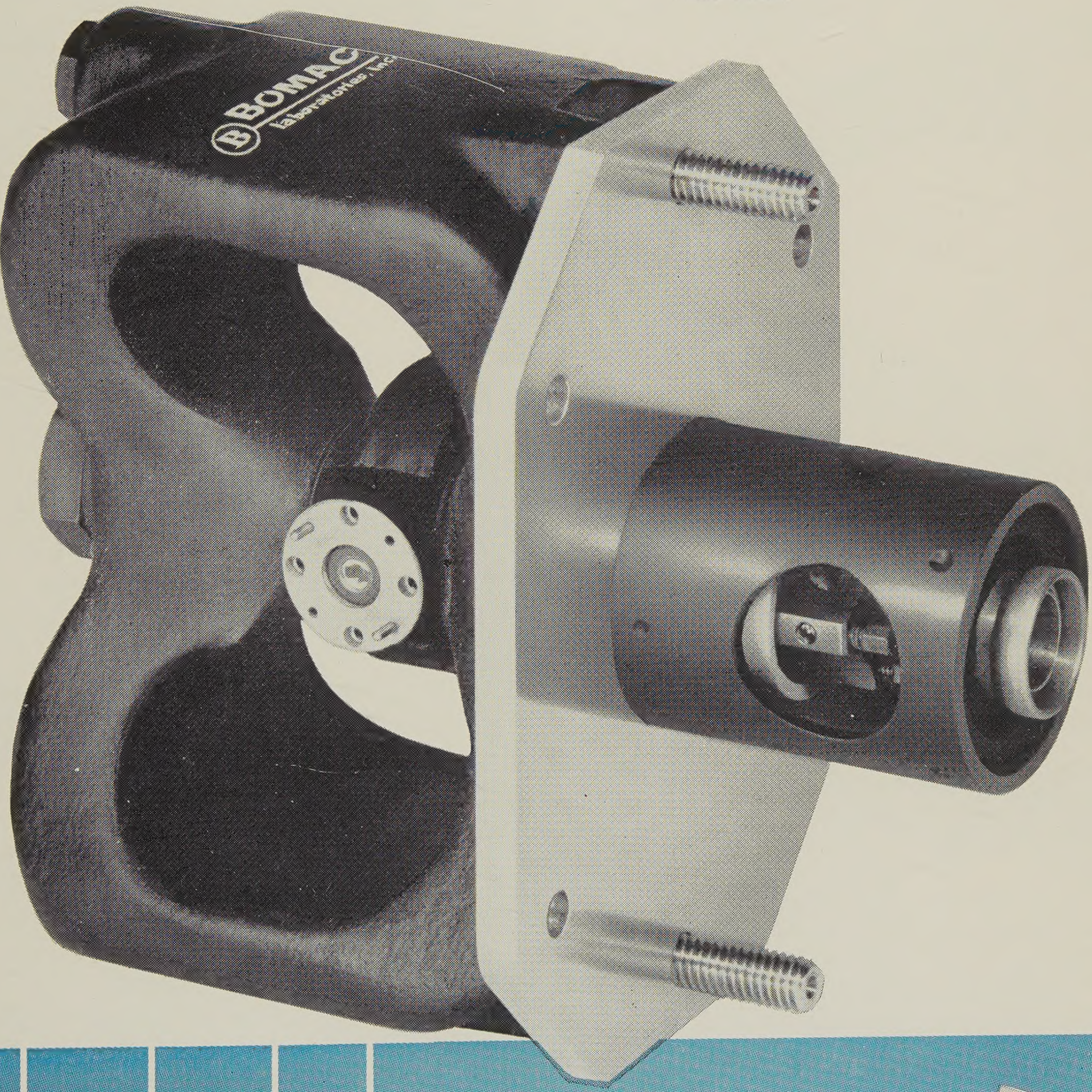

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Maximum	*1.0 db*	*2.0 db**
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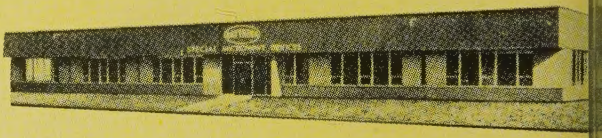

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